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ABSTRACT

This document contains the following 16 papers presented at a conference on teaching technical education and technical literacy: "British School Technology and the Industry Education Unit" (Eric Bates); "The Development of Technological Education through Bedfordshire Local Education Authority to British School Technology" (Ron Denney); "The Illinois Center for Technological Literacy: A Response by the University of Illinois" (Thomas L. Erekson); "Technological Literacy through Educational Technology" (Minaruth Galey); "Technological and Civic Literacy: Symbiotic Relationship" (Anthony F. Gilberti); "Technological Literacy through Use of the Computerized Library" (Charlene Grass); "Mathematics: The Misunderstood Language of High Technology" (W. J. Haynie III); "Integrating the Systems of Technology" (Ronald E. Jones); "Technological Literacy: An Educational Challenge" (Franzie Loepp); "OM: College/University Creative Problem Solving Competition" (C. Samuel Micklus); "Technology Education in Southeast Virginia's Public Schools" (John M. Ritz, Robert F. Head, Paul L. Cummings, and James R. Doyle); "Assessing Students' Technical Reading Skills" (B. June Schmidt); "Technology Literacy Test" (Lee Smalley); "Beyond Tasks and Competencies to Problem Solving in Technology Education" (John C. Thomas); "Technological Literacy: An International Perspective" (Ronald D. Todd); and "A Leadership Model for Implementing Technological Literacy Education" (Robert E. Wenig). (KC)

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Technology Education Symposium

PROCEEDINGS

"Technological Literacy: An Educational Mandate"

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Technology Education Symposium

PROCEEDINGS

"Technological Literacy: An Educational Mandate"

Edited by
Mark Sanders

Virginia Polytechnic Institute & State University
Blacksburg, Virginia
October, 1986

Preface

Technology Education Symposium VIII represents another in a progression of important symposia sponsored by the technology education/industrial arts community. From the first Symposium in 1980, the format has provided a unique forum for professionals in the field to share their ideas regarding the education of America's youth, for and about the technological world in which we live.

Throughout the first three-quarters of this century, industrial arts educators viewed themselves as *the* delivery system, within the general education arena, for content relating to industry and technology. From the onset, we were a profession committed to teaching about the "arts" of industry at a time when "arts" held much the same connotation as "technology" holds today. And, by and large, we were the *only* discipline wrestling with ways and means of teaching America's youth about the "nuts and bolts" of our society.

With the evolution of our so-called "post-industrial" society, there are (suddenly) a number of other disciplines interested in teaching young people about technology. No longer are technology education/industrial arts professionals, the *only* players in this arena. Indeed, the stampede of others to this cause leaves us wondering if we are still even the *central* figures pursuing the goal of "technological literacy." Suddenly, it seems as though *most* disciplines are joining our cause, as well perhaps they should, given the "technological" component of virtually all disciplines.

In its rather brief history, the Technology Education Symposium has been of, by, and for industrial arts/technology education professionals. In view of the aforementioned activity in other disciplines, the Symposium has remained a relatively provincial "small circle of friends." With this in mind, the Symposium VIII Planning Committee, Allen Bame, Lynn Barrier, Bill Dugger, Jim LaPorte, Charles Pinder, Arvid Van Dyke, and myself made a conscious effort to "open up" the Symposium, thereby extending the dialog to other disciplines. A "Call for Papers" published in *The Chronicle of Higher Education* resulted in a somewhat more heterogeneous mixture of proposals, with authors from such disciplines as Library & Information Science, Business Education, and Curriculum & Instruction as well as an international contingency from the United Kingdom and the Netherlands. Proposals were channelled through a formal review process, and the *Proceedings* published for distribution at (rather than after) the Symposium.

This latter alteration has been challenging from a logistic standpoint, and would no doubt have been impossible wiyhout the cooperation of the authors, secretarial staff, and appropriately, *technology*. Special thanks to Brenda French, Cheryl Mallen, and Patti Hall who keyboarded the entire document on the IBM mainframe computer at Virginia Tech in a matter of days. The *Proceedings* were output via the "Advanced Function Printing" option on the IBM 3800 laser printer.

I mention these esoteric technologies for two reasons: As "technology educators," we often take interest in this sort of technical minutia. More importantly, this *Proceedings* simply would not exist in its current ("near typesetting quality") form, were it not for the marvelous capability of our technology! The document was completely keyboarded, edited, proofed, corrected, and output as camera-ready copy in less than a week! Moreover, the computer was totally responsible for pagination; that is, there was absolutely *no* paste-up involved in the production of this *Proceedings*! After a decade of teaching graphic communications, you'll forgive me if I find that rather awesome!

A final word regarding "technological literacy." The Symposium VIII logo (on the cover) includes a graphic representation of the ASCII code for #8, which seemed, somehow more appropriate than the ancient Roman numeral VIII. Are those who did not catch that "technologically illiterate?"

Mark Sanders
Proceedings Editor

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British School Technology and the Industry Education Unit

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United Kingdom

Introduction

The philosophy of the Industry/Education Unit is first to identify an education need and second, within its resources, to do something about it. The Unit is therefore concerned about getting results.

One area where the Department of Trade & Industry, through the Industry/Education Unit, has made a major impact is through British School Technology. It is not my intention to rehearse the "problems" which led the DTI to propose the establishment of BST to colleagues within the Department of Education and the Manpower Services Commission. The shortage of suitably trained teachers and technicians, the cost of initial equipment and then keeping up to date need no elaboration. Nor does the problem, still with us, of gaining full acceptance of 'Technoolgy' by many parts of Higher Education in the same way it is welcomed by Industry.

However, solutions did exist either to solve or alleviate the worst difficulties schools and colleges were facing. These were practical solutions involving in-service training, environmental change, curriculum development, and unique delivery methods to overcome both the shortage of trained staff and deficiencies in equipment.

BST, therefore, grew out of sound practical experience within the Education Services and the Industry/Education Unit was pleased to propose its formation to Ministers with a wide but practical brief.

Remit

The major remit of BST is to be a national focus for advice and consultancy to Local Education Authorities and others planning to introduce technology courses and to develop technological activity in general. This wide brief was deliberate, as was the very practical nature of its detailed functions:

- to undertake a programme of in-service teacher training for technology in the curriculum;
- to lead curriculum development in technology;
- to undertake training of technicians;
- to develop materials and equipment suitable for the technology education markets, either singly or in association with other suppliers; and
- to manufacture and convert mobile technology units to aid the practical delivery of technology within the curriculum.

Achievement

DTI is concerned with achievement, and now that BST has been in existence for two years, can it be called a success?

Although BST has some way to go, it is well on course. It has every right to feel pleased with its first two years' activity and I would be the first to proclaim them successful. Examples of its achievement include

1. Over 80% of Local Education Authorities have made use of BST's services.
2. Mobile Technology Units are on the roads as far apart as Cumbria and the Isle of Wight; Lothian and Devon; North Yorkshire and Avon.

3. Product development is on the way and beginning to provide a vital service to schools and LEA's. Even sales of low cost consumable wheels for technology project work now exceed 150,000.

4. If success is measured by external interest, then BST has arrived, with details of its operation being sought in Europe, United States, Canada, the Middle East and several institutions in Australia.

During visits to Western Europe, the Indian Sub-continent and the United States, I have found surprise and perhaps a little envy at our achievements in the UK. I have nowhere seen any comparable programme and nothing can approach the quality and range of the hardware we can offer schools.

So if BST is being successful on the road to a final goal, what then is that final goal? I would like to outline three major goals for BST.

1. BST must continue to be an organization whose paramount task is to support the activities of teachers, schools and LEAs in delivering a modern technological education. I am convinced that its success to date is because its staff is among the best in the country. They are almost all from an educational background and combine considerable technical expertise with an understanding of the practical needs of teachers. It can provide advice on materials and equipment - both to education and to the suppliers of that equipment - which is completely unbiased because of BST's independence from any individual market.

2. Its second goal - and one specifically given to BST by Central Government - is to become self supporting. Until it is doing that, its success will be regarded as only partial. However, BST did 10% better than expected on its financial target for 1985/86 and this is a good augury for the current financial year.

3. My third goal for BST would be to ensure that the organization never in fact sees itself as having arrived at its goal! In other words, the task of promoting and developing technological education in the United Kingdom is continuous and expanding.

We need to ensure that every boy and girl has the opportunity to study technology in schools; technology which includes those aspects of design and quality which help develop attitude of mind and which is concerned with getting the best results and solving problems in the most cost-effective way. These should be an integral part of every pupil's education, whether or not he or she becomes an engineer or technolgist in later life. In the meantime, there are major problems requiring urgent action. For example, there are major worries regarding initial teacher training of technology students and a number of Government Departments are looking carefully at that major issue.

Summary

British School Technology has made a good start. It deserves the help and assistance of colleagues within Local Authorities to ensure an even better service. It is those colleagues in LEA's and schools who can feed necessary ideas through to BST; who can provide examples of good practice; who can indicate products which might be developed; who can advise on the tailor made courses they would like; who can indicate improvements to any products produced or supported by BST.

The Industry/Education Unit is proud to have instigated the formation of BST. Its success will depend upon its own efforts - and the active participation of its customers.

The Development of Technological Education Through Bedfordshire Local Education Authority to British School Technology

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Some seven years ago, Bedfordshire Local Education Authority (LEA) recognized the need for an education which would be revelant to the pupils, relevant to society, and relevant to a changing, industrial pattern. This paper attempts to show how a traditional Shire, English County, in less than five years, provided for *ALL* its pupils, a structured provision in all its schools in the 8 to 18 age range.

General Statement

Design and Technology should provide the opportunity for improving the balance between theoretical and practical aspects of the curriculum. The workshops provide a fertile environment where basic theoretical knowledge can be applied and developed and the skills learned elsewhere reinforced in an atmosphere more closely related to the world outside the school. This provides a sound motivation for learning and emphasizes the value of divergent thinking. While all these considerations are vital for personal devleopment, they also have important implications for the preparation of pupils for further and higher education and industrial life. Design and Technology can help to prepare young people to take their place in the world of work, but, at the same time, it develops positive attitudes and abilities towards the productive use of leisure time. There are some young people lacking a positive sense of personal identity and Design and Technology, through experience of success, can make an important contribution in this respect. An important requirement for an informed democracy is the appreciation by all of the potential of technology.

Primary Objectives

1. To provide occasion for the pupil's natural desire to handle and use with confidence the materials and resources of his environment.

2. To preserve and exercise the individual pupil's powers of imagination, inventiveness and initiatve, by presenting him or her with problems involving the use of such materials and resources.

3. To heighten the pupil's awareness of the opportunities and problems and accompany the continuous growth of the technological world and to prepare him or her to cope with it.

4. To build up the pupil's confidence by illustrating the capacity of Design and Technology to solve such problems.

5. To develop the means of communication.

County Design and Technology Structure

The "Bedfordshire Structure" and the establishment of the Technology Unit at Ampthill, in the centre of the County, are, to quote the media, "The main contributory factors to the success of developing Design and Technology in the country in such a comparatively short time."

The heart of this is communication at all levels, enabling the Education Service to be aware and

informed of operation, management decisions, developments, problems and successes.

This has enabled the whole of the Technology operations to be housed under one roof, i.e. Resources, Central Technology Workshop, In-Service Education, Design and Technology Mobile Units and Technology Development.

It must be emphasized that the majority of the conversion work was carried out by our technicians with the full support of the County Architect's and Surveyor's Departments. It is truly a team approach.

The Structure

This fundamental approach is that of a "Nuts and Bolts" operation, an operation that will work, an operation run like a business to succeed. For with a pupil's education, it must be right the first time. There is no second time around.

The overall structure is divided into four major areas (See Figure 1 for specific structure).

1. Curriculum
2. Inset & training for that curriculum
3. Cost effective resourcing that curriculum
4. Creating the environments to teach that curriculum

Education Technicians - Technology

The Central technician service, besides "getting things done" quickly and efficiently, operates predominantly in the following ways:

Breakdown Service - Design and Technology: Briefly this consists of repairing equipment both mechanically and electrically when reported by the School, Inspector or other Agency within the service. A high degree of efficiency is maintained, particulary at the time of external examinations which can be stressful.

Complete Workshop Insallations and Resource Development: This work consists of positioning, bolting down of machines and other equipment, three phase, single phase, 110 volt installations, earth leak trip systems, low voltage lighting, and tranformers, which virtually means taking a "shell" workshop and fitting it out completely. This has been invaluable with the changeover to middle schools and the introduction of technology areas.

With the introduction of the Health and Safety Acts of 1974, the technician service has kept the highest standards of safety throughout the service with efficiency and cost effectiveness.

A good relationship has built up with H.M. Health and Safety Executive through the joint solving of guarding problems to equipment.

There is a planned programme of machine overhaul and rebuilding. This involves the disconnection of supply, removal from the school site by low loader, complete stripping, re-assembly, spraying, testing, return, re-sitting, connection of supply and testing on site. This has resulted in substantial savings in equipment.

From time to time, technology equipment is designed and made for in-service courses when, because of the advanced nature of developments, it is impossible to obtain from industrial suppliers. A recent example is a series of automation production lines for A-level Technology which were made for a course and subsequently used on the Mobile Units and lined with computers.

During the development years, the technicians were responsible for the gutting and fitting out of the Mobile Technology Units.

Provision has been made for a complete tool and cutting service for schools, providing for the sharpening of wood tools, including the making up of bandsaw blades, the grinding of circular saw blades and the provision of a loan service while this is being carried out. Automation is utilized as far as possible as part of these operations.

Because, from time to time, emergencies arise when an architect requires the rapid disconnection and removal of machines, priority is given to this service from Ampthill. This has led to close co-operation with the Engineers Section of the Architects' Department with resultant respect and trust.

Provision for the Middle Years (8-13 age range) Foundation Years

It has been of concern that with some Upper Schools (13-18) having up to seven feeder schools, there was no structure for courses in Design and Technology. This meant that the work done in Middle Schools was largely written off because of its diversity.

A set of Aims and Objectives has been produced by a committee of teachers from both Middle and Upper Schools which is gradually being accepted across the County.

Aims

1. To develop an understanding and appreciation in the pupils of technological and industrial development so that they, as citizens of the future, will be able to exercise control over them.

2. To enable pupils to experience all, or part, of the technological process so that they understand how

   - decisions are made and

   - conflicting factors are resolved in various situations as well as to develop a confidence to solve problems that they will face in the future.

3. To promote the development of initiative, ingenuity, resourcefulness, self-involvement, co-operation, social responsibility and the ability to communicate.

Objectives

The pupil should, in simple terms, be able to:

1. analyze and evaluate a problem;

2. record relevant information;

3. apply knowledge gained with their experience to solve a problem;

4. formulate a number of ideas for the solution of a problem;

5. develop the most feasible of a number of ideas to a solution;

6. communicate ideas in an appropriate manner;

7. assess and evaluate a finished product;

8. discriminate abetween existing solutions to the same problem;

9. plan the production of a job;

10. use skills and techniques appropriate to the materials;

11. be critical of personal standards of work; and

12. use tools, machines and materials with care and safety and be aware of the social responsibilities involved.

These broad Aims and Objectives equate into a structured course giving skills in:

1. Communicatin, both verbal and graphical;

2. Study - the retrieval. collation and use of information;

3. Technology and Science, which include basic electronics, mechanisms, simple pneumatics and hydraulics, materials and structures and control;

4. Design Management - the discipline of designing and making, giving a specific need;

5. Application of ideas; and

6. The manipulation of materials and tools.

This change in the Middle Years curriculum is being brought about because

1. The Technology Unit team has been able to effect changes in the workshop environment in terms of layout, new rooms, safety, types of machinery installed, quality of benching and hand tools.

2. Teachers in the Middle Years are specialists for Design and Technology, as the Middle Schools are deemed Secondary.

3. The number of in-service courses run by:

   - Technology Unit at Ampthill;

   - Colleges of Higher Education in Bedford and Luton;

   - Area Workshops based at specific schools; and

   - The Middle School Mobile Technology Unit.

4. Central back-up in the form of:

   - Advisory help from the Inspector of Design and Technology and his team;

   - Technician help for the repair and maintenance of tools and equipment;

   - A loan service to schools of technology equipment and kits;

- Booklets and teaching aids produced by the staff of the Technology Unit; and
- Funding for certain items of equipment which would otherwise prevent a school starting the curriculum change.

5. Headteachers are in many cases looking at their time-tables as a whole and adjusting them to allow more advantageous use of the time for Design and Technology. Several members of staff from various 'departments' find themselves teaching some aspects of Design and Technology because of the recognized overlap of the subject into their areas. In some cases this has caused a revision of the 'carousel' system.

6. There is a true enthusiasm which has been generated by the changes in the curriculum. This is an enthusiasm starting with the Chief Education Office, his Inspector and the Technology Unit team through to the various schools, the teachers and their pupils. This really is the strength of the subject.

The County provides a variety of in-service courses for teachers, from Machine Safety Courses to Modular Technology. The most useful courses have been those which have been based in the schools as Area Workshops, because teachers from the Upper and Middle Schools can work together on a common purpose.

The provision of a Mobile Unit by the Industry Education Unit of the Department of Trade and Industry, and the equpiment by various manufacturers has enabled the impetus for change to be accelerated. The idea of the 'Middle Year Bus' is for it to go into schools driven by its highly qualified teacher and to take the Design Technology teacher and his or her class out.

The 'Middle Years Bus' is currently serving ten schools (half day per school per week) which is approximately one quarter of the County's Middle Schools.

Mobile Technology Units

With the successful introduction of G.C.E. O-Level Examination in Technology in the County, and the subsequent demand for an appropriate A-Level Examination, the problem arose of providing high-powered computer aided technology for relatively small numbers of pupils spread over a number of schools.

The answer was to fit out a mobile classroom-laboratory with the type of equipment a school cannot buy in any quantity, with a first class teacher and give it the back-up support of staff, teachers, technicians and industrial contacts and then share it between the first half dozen pioneer schools.

With the success of the first unit and the help of the DoI (Department of Industry - now the Department of Trade and Industry - DTI) two more Units were purchased, one for the Middle Years (already described) and one for the extension of A-Level Technology to cope with all the County's Upper Schools. These Units are both double decked!

Teaching and driving is exciting and fast moving, providing evidence to support the motto of the Unit - "Tomorrow Won't Wait."

Predictably the project has aroused a great deal of interest and increasing numbers of able students are electing to take the Cambridge Technology A-Level along with their Mathematics and Physics. At the moment, the Computer Buses do a four-day week in schools returning on the fifth day to the Design Technology Unit where the team runs day release In-Service Training as well as evening courses.

There have been no real teething troubles. By concentrating the County's resources in a Mobile Unit, it has brought the latest in educational technology into the schools for the minimum cost (much of the hardware was already in central stock - most of the software is written by the students).

The Bedfordshire Mobile Unit is a dynamic solution to the conflicting demands for highly qualified teachers in a new subject, expensive and constantly changing equipment and economic stringencies.

BST/Bedford

What has been clearly identified is the ability to replicate this "Bedfordshire System" on a national scale. So with immense vigour and energy, help was sought from Central Government to establish a means of offering the same facility that Bedfordshire enjoys to other Local Education Authorities throughout the country. The result has been the establishment of a national unit in a quite unique way. The finances

and support for the Unit have been forthcoming from a tripartate system incorporating assistance from the manpower Services Commission and the Department of Trade and Industry in a financial way and a great deal of help and support from the Department of Education and Science. The programme that resulted form this co-operation is projected under the title British School Technology, Bedford.

At BST/Bedford, a system and organization has been developed which can do precisely what is required, that is the replication of the Bedfordshire System for other Education Authorities. The Unit is led by Mr. Ron Denney, OBE, who has spearheaded the Bedfordshire operation. The Unit has a number of specific briefs, but its major role is in the development of mobility in technological education.

Consultancy

BST/Bedford, through its Director is able to offer a wide range of consultancy services to potential clients. Our clientele to date have come from a wide spectrum within education: these include the consultancies in liaison with the Inspectorate and Advisory Colleagues within Local Education Authorities for individual schools.

BST/Bedford are also undertaking a number of consultancies a) for schools within the independent sector and b) for companies with regard to industrial training systems.

BST/Bedford divide their consultancy into four specific areas which they find can adequately cater to most of the needs of their clients. These areas are a) Curriculum, b) Resources to service the curriculum, c) The further training of teachers to teach that curriculum, and d) The environment in which that curriculum will be taught.

A vital part of any curriculum development within the field of Design and Technology will be judged not on its short term development but extending that through to medium and long term. It has been proven over the last seven years that a very effective way of ensuring continued development is to adopt a structured system which enables an authority to support its teachers.

This can be done through central resourcing and it is with such a structured system that authorities have been able to take a quite spectacular and rapid progress in this curriculum area.

BST/Bedford is able, through its consultancy team, to offer a structured system which can be adopted and adapted to the needs of individual LEA's. An integral part of such a structured system could be the development and use of Moblie Technology Units which enable the authority to input resources very economically and undertake in-service training in their school based systems.

Courses

For the in-service training of practicing teachers, BST/Bedford is able to offer a full range of course facilities at their premises at BST/Bedford. They have residential accommodation for up to 25 people and their courses are very much geared to the needs of the LEA and/or individual companies.

They are, of course, able to offer standard packages of courses but much prefer to be able to tailor the courses to the needs of the particular clients. Their principal aim is to enable members to develop their own breadth of knowledge or skills and of insight into curriculum needs, thus being able to go back to their teaching environments with the ability and design actually to develop their curriculum in a practical manner.

Design Services

The primary purposes of BST Design Services are

1. to arrange the design and manufacture of equipment which cannot be obtained elsewhere without difficulty.

2. to evaluate existing equipment.

BST staff are well placed to provide practical advice on the needs of LEA's and companies offering an education service: all have been seconded from teaching/advisory posts with education authorities. Design Services employ the full capabilities of the BST work force and is headed by qualified industrial designers.

Design Services available from BST include:

- Design and development of Mobile Units - including interior layouts, fittings and finishes, product development and external livery. A full design and application service is available.

- Interior Design of workshops, laboratories and classrooms. They offer a full consultancy service.

- Links with Industry - BST/Bedford is keen to aid the development of product ranges appropriate to a 20th century curriculum. To this purpose BST/Bedford offer to companies wishing to provide a service to education:

  1. Aid and advice on teaching requirements.

  2. Design and development advice and evaluation of equipment.

  3. A full product design service from concept to prototype development and manufacture.

  4. Industrial modelling.

- Product Design - A full product design service is available with a full capability of solving educational needs, from conceptual work through to prototype development and product manufacture.

There are many ways to deliver a Technology and Design education programme. This paper has given one approach which we have found to be successful and exciting. However, many others could reach the same goals but all must bear in mind that the challenge of today's culture is above all the challenge to our capacity to change, not simply by positively adopting to the most dominant forces at a given period, as in evolutionary change, but to change in such a way that the human values and standards which are evolving in our culture are retained and their future devlopment safeguarded.

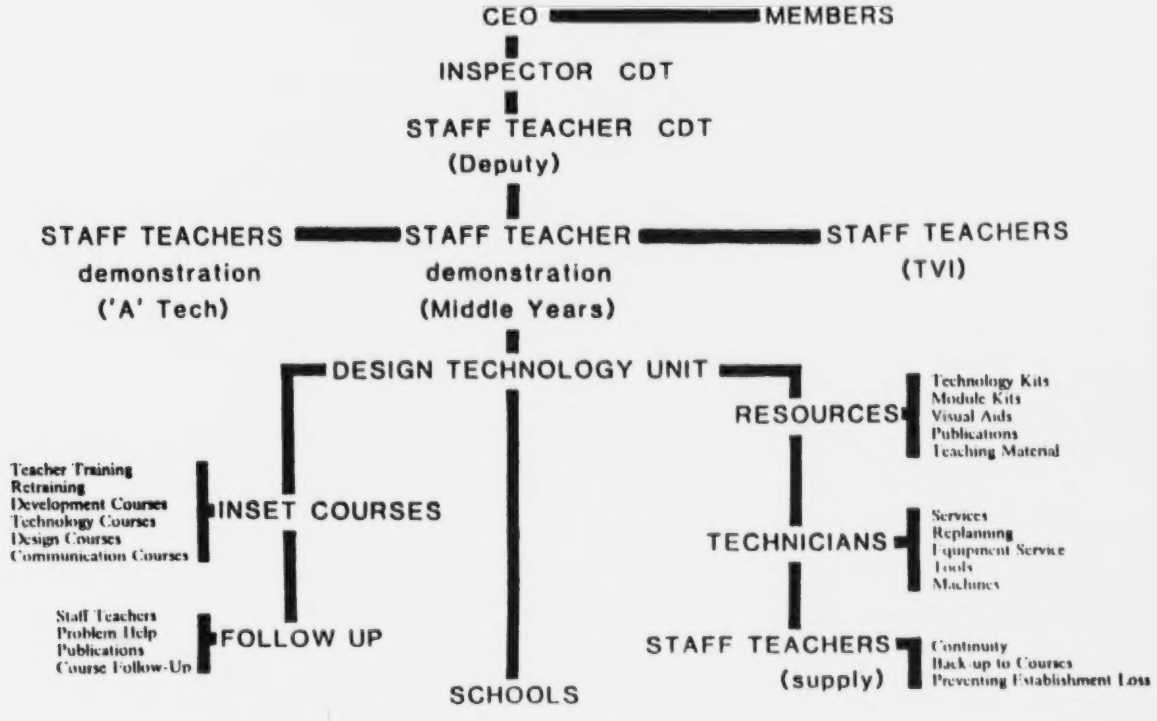

Figure 1: Design Technology in Bedfordshire - Structure

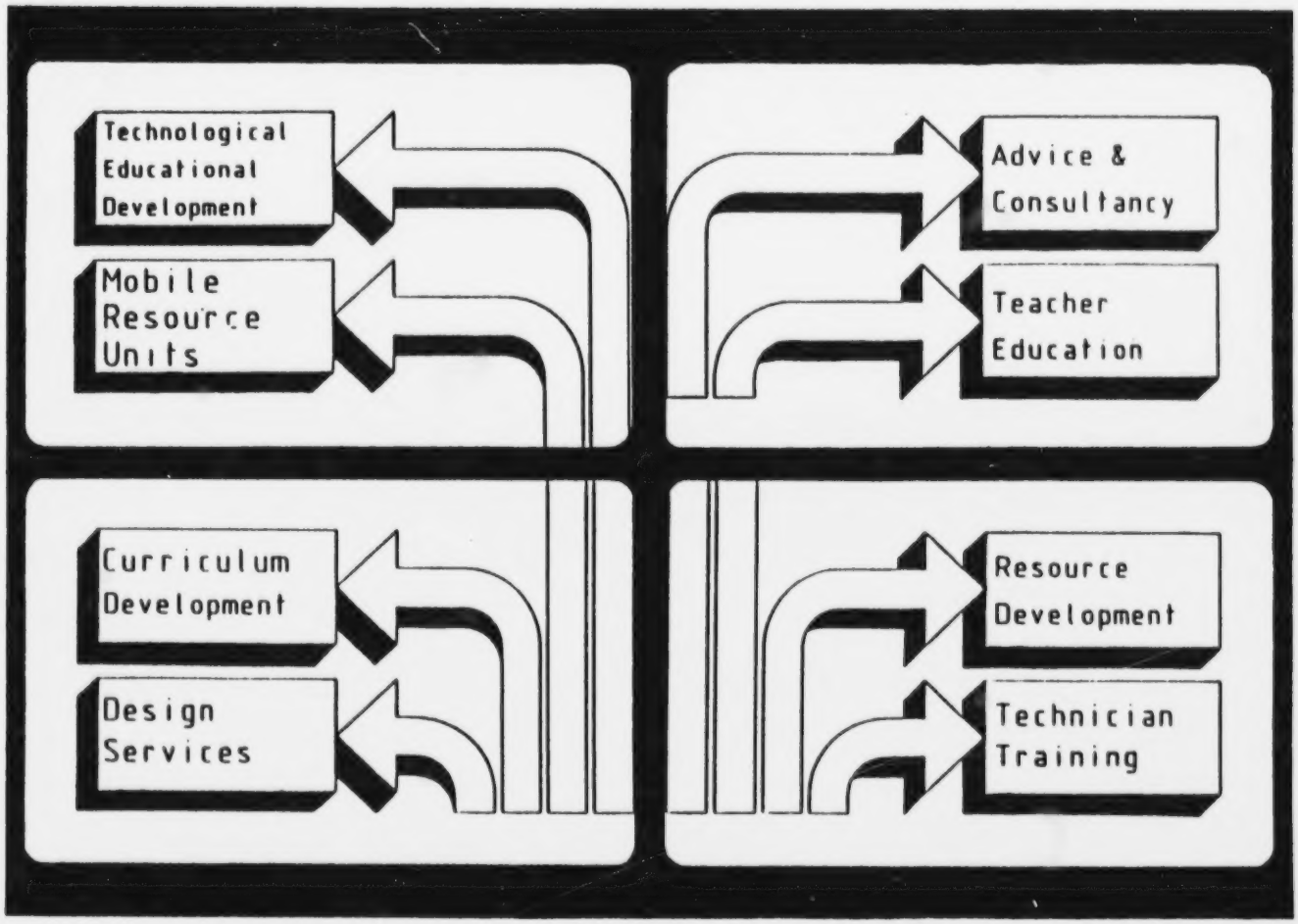

Figure 2: Design Technology in Bedfordshire - Structure (Continued)

The Illinois Center for Technological Literacy: A Response by the University of Illinois

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The transition from the industrial-based society to an information-based society has had, and will continue to have, significant impact on the way Americans live, learn, play, and work. The shift to the information age has come as a result of a "knowledge explosion" and the application of new knowledge and principles to the production of goods and services. The knowledge explosion has produced technological change in our nation that requires workers to frequently upgrade their skills to accommodate technological innovations.

Technological devices and innovations in the future work place will require major policy shifts in education. Future workers will need to have a broad base of knowledge and understanding of basic processes and systems, as well as the ability to be flexible as technology continues to change the nature of work. Additionally, future workers will need to have a broad technical background and an understanding of the role that technology plays in our lives and society. Thus, education needs to assure that future graduates are "technically" literate.

Technological literacy has been difficult to define in precise terms -- it means different things to different people/groups. For purposes of this paper, technological literacy will be defined as "the ability to intelligently use technology and understand its development, applicaion, and social impacts." To achieve technological literacy, education will need to prepare people with broad-based interdisciplinary skills and knowledge through well designed programs. Major instructional, curricular, and facility revisions will be required to meet these futre demands and challenges. To address these challenges, education will need to have highly qualified, technologically literate teachers who are prepared for the challenges of the future through well designed teacher education programs.

Education and Technology in Illinois

The need for strategic planning as a result of technological change for education has been well documented in Illinois. The Illinois State Board of Education (ISBE) established, funded, and directed the "Education for Technology Employment" (ETE) initiative to address the issues of meeting the needs of students peparing for work in a technological era. This initiative included curriculum, staff, facility, and support service components to improve vocational and technical education programs. The ETE project included participation by eight local planning demonstration sites (consortia of high schools and area vocational centers) and two university-based sites. Technological curriculum materials have been developed through this initiative in the areas of CAD, CAM, Electronics, and Information Processing.

The state of Illinois also has been a participant in the "Principles of Technology" (PT) curriculum project. The intent of the PT project has been to develop a vocational- technical physics curriculum to complement vocational education programs by providing students with skills and knowledge about the application of scientific principles to the world of work. PT is undergoing further field testing at nine additional high schools in Illinois during the 1986-87 school year.

Another curriculum effort to deal with teaching technology is the "Illinois Plan for Industrial Education." A major focus of this curriculum effort has been the development of four "systems" courses for grades nine and ten -- Production Technology, Communication

Technology, Transportation Technology, and Energy Utilization Technology. These system courses utilize a math/science/technology base rather than the traditional materials or crafts base of prior industrial education curricula. These courses have been well accepted in Illinois and have received national attention. It has been demonstrated that more than 50% of the content is math/ science and these courses may be used to meet state high school graduation requirments for math and science (if approved by local school boards).

Technological Literacy and the University of Illinois

The technological curriculum efforts in Illinois have, for the most part, focused on the secondary school level. Universities, such as the University of Illinois, have had a direct involvement in these curricular efforts. In addition, the University of Illinois has been directly involved with the discovery, development, and use of technology. In fact, the faculty at the University of Illinois have conducted much of the research that has been used as the basis for many technological innovations. The following are examples of the high level of technological involvement at the University of Illinois:

1. Computer-assisted-instruction was first developed at the University of Illinois in the 1950's (PLATO) and now is the world's largest computer-based instructional system.

2. Illinois was one of the first universities involved in the development of the computer.

3. Illinois established the Center for Supercomputing Research and Development and the National Center for Supercomputer Applications.

4. Illinois has received a $40 million donation to build the Beckman Institute for Advanced Science and Technology, and interdisciplinary research center to study intelligence -- both biological and artificial.

5. Professor John Bardeen, Physics Department, is the only person who has won the Nobel Prize for Physics twice.

Realizing that these technological involvements only scratch the surface of the technological developments at the University of Illinois and considering the University's international reputation for excellence, one would logically assume that all students are exposed to and involved with a high level of technology -- thus, technologically literate upon graduation. This assumption is not valid given the wide range of programs and the theoretical nature of many programs. In effect, students in engineering and the hard sciences develop a "theoretical" level of technological literacy and students in other majors, including teacher education students, become technologically literate more by accident than design.

Illinois Center for Technological Literacy

To effectively address the issues of technological literacy and improve pre-service teacher education, the Division of Industrial Education, Department of Vocational and Technical Education, College of Education, University of Illinois at Urbana-Champaign, proposed the establishment of the "Illinois Center for Technological Literacy." The Illinois Center for Technological Literacy will be established in the former industrial education laborabory (Room 38 Education Building). The overall objective for the Center is to develop a flexible, hands-on technology laboratory for the delivery of courses/activities to help students and teachers become technologically literate. The Center will have three major research and service components:

1. a pre-service teacher education component to facilitate the revision of the undergraduate industrial arts teacher education program at the University of Illinois through the development of a technology teacher education program that will mesh with national changes in teacher education proposed by the Holmes Group;

2. an in-service component to provide effective in-service education for industrial arts/technology education teachers through Summer Institutes for Technological Literacy; and

3. a strong research and development component to conduct research on how to effectively integrate technological literacy with the academic subjects.

The following descriptions of each of the components are provided to briefly describe how the overall objective will be met.

Pre-service Teacher Education: The pre-service teacher education component will include the revision and revitalization of the undergraduate industrial teacher education

program at the University of Illinois to prepare teachers with the knowledge and skills requisite to teach technology as it relates to employment focusing heavily on the ability to teach the Illinois Plan for Industrial Education and the Principles of Technology. Core courses in the technology areas of the Illinois Plan will be developed and delivered in the Center. In addition, a Current Technological Developments course will be developed that will utilize a seminar format where faculty, graduate students, and personnel from industry will be invited to describe/discuss the most recent technological innovations. The intent will be to develop a model "technology teacher education program," based upon the "best" thinking, research practice and evaluation, that may be adopted at like institutions in the nation. This component is especially relevant given the recent report of the Holmes Group and the changes it suggests for teacher education at major research universities.

The pre-service component will also include the establishment of a technological literacy course (a laboratory-based course with practical applications of math, science, and technology) for math, science, social science, and other elementary and secondary teacher education programs at the University of Illinois. This emphasis will be to improve the preparation of teachers who will be providing related academic instruction to students in schools.

Inservice Teacher Education: Industrial education faculty with advise and input from the advisory committee will develop a comprehensive proposal for a Summer Institute for Technological Literacy to be held summer 1987 at the University of Illinois. The Institute will include at least three areas of activity: (a) a structured set of technological activities utilizing bench-type technology, (b) a set of technology visits to on-campus technological research and development laboratories (e.g. Supercomputer Center, CERL-PLATO), and (c) a set of technology visits to private sector industries that are technology oriented to see technology in action. The Institute will give special attention to the integration of the Illinois Plan and the Principles of Technology into the industrial education programs in Illinois. Teachers attending the Institute will leave with the following: (a) a set of up-to-date technological experiences, (b) a model of how to transform a traditional high school shop into a technological literac center, (c) knowledge of how to link the technological literacy center with the academic subjects at his/her high school, and (d) curriculum materials and experiences to facilitate the integration of technologiy into the industrial education instructional program.

Research and Development: The research and developlment component will provide opportunities for research in the acquisition of, instructional methods for, and testing for technological literacy. Research on teaching and learning technological concepts will be conducted in cooperation with the Beckman Institute. The research component will also include an emphasis on evaluation-- evaluation of the model pre-service and inservice programs and evaluation of the Center itself.

Financing the Center

As an indication of support for the establishment of the Illinois Center for Technological Literacy, the College of Education made a commitment of a faculty member, full-time, for two months in the summer of 1986 with the charge to establish the Center and begin the pre-service curricular revisions. In addition, a grant in the amount of $22,500 has been awarded by the Illinois State Board of Education, Department of Adult, Vocational and Technical Education to assist in the development of the Center. Other sources of funds, both internal and external to the University, will be sought in the future to equip and staff the Center.

Status of the Center

To date the Illinois Center for Technoligical Literacy has been established in concept. The physical facilities (laboratory modifications) are being planned and initiated at this time. New equipment and supplies are being ordered and the Center should become operational for the Summer Institute 1987 and regular classes in Fall 1987. The following procedures were followed in establishing the Center:

1. A conceptual framework for the Illinois Center for Technological Literacy was developed in draft form by Industrial Education Division faculty.

2. A committee to react to the conceptual framework and to advise the Industrial Education Division concerning course and program revisions, facility modifications, and so forth, has been established. Membership for this committee includes nationally recognized leaders at all levels to help establish a philosophical and opera-

tional framework for the Technological Literacy Center and the Technology Teacher Education program.

3. Written documents and proposal to officially establish the Illinois Center for Technological Literacy were prepared by Industrial Education Division personnel.

4. New and revised course outlines have been prepared and submitted to departmental and college curriculum committees for approval.

5. Major facility modifications and changes to establish a bench-type "technology laboratory" at the University of Illinois (Room 38 Education Building) to present a model technology lab for future teachers have been planned and are being implemented within the financial constraints of the University.

6. A "technological literacy" course designed for students preparing to become math, science, social science, and other elementary and secondary teachers to enhance the related academic preparation of future high school students is being developed and will be submitted to curriculum committees for approval. The intent is to have this course taught by industrial education faculty in the redeveloped technology laboratory.

For Further Information

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Technological Literacy Through Educational Technology

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Our highly developed technological society is markedly different than the industrial society in which adults in this country grew up and were educated. Whether we call our current era the Post-Industrial or the Information Age, we recognize that great changes have occurred and are continuing at a rapid rate.

Our students must grow up, work, raise their families, and vote on technological issues that affect every part of their lives in this society. Yet this is little systematic effort to help them learn about this new era by learning of the interactions of technology and society. Let us emphasize here that this knowledge is needed by everyone in the United Stated today -- not just those in the field of engineering, but also ministers, social workers, and every citizen of this nation.

Our schools are the designated institutions to provide literacy of all kinds for our children. The need to understand technology and its roles in society is certainly well-recognized. In fact, it is proclaimed by a stream of reports from blue-ribbon commissions. In 1984 alone, ten major studies of educaiton were reported, including *The Unfinished Agenda* by the National Commission on Secondary Vocational Education, each one calling for changes in school to prepare our students to live in a technological society.

The need to prepare students for new kinds of work in that technological society was recognized early by vocational educators and leaders of industry. New Jersey's Technology for Children and Virginia's Exploring Technology were important efforts in upgrading and updating vocational education. Those early efforts to meet the needs of the students and industry are continuing and new ones are appearing.

One of the new efforts is a national curriculum project, titled You, Me, and Technology (YMT). Its subject matter is new for the secondary schools of this country -- science, technology, and society (STS). This field of study does include a few principles of technology and a few of science, but it is primarily the study of the mutual interactions among science and technology and societies.

STS is easily recognized as providing insight into almost all areas of human activity, because technology has impact on almost all of our lives. STS is truly a multidisciplinary subject area with applications for all subject areas in secondary schools. However, You, Me, and Technology is directed to the teaching of STS while recognizing the value of STS in teaching other subject matter in the curriculum.

As educators are meeting in their respective states to develop the curriculums for technology education, they recognize the need to show the students the connections between what they are learning in the classroom and their lives now, and in the future. STS serves very well in that role of adding meaningfulness and importance to their classroom experience as well as understanding to their lives.

Development of the YMT Curriculum

The content of the curriculum provides a broad overview of the field of STS to serve as an introduction to the entire field. The writer began developing the YMT curriculum by selecting three nationally known experts in the field of STS to serve on the design team. In a three-day meeting with the writer, the designers completed the assignments of writing the goals, objectives, principles, and content outline.

The goals of YMT are identified as:

- To develop technological literacy, that is, an awareness of the methods and general principles of modern technology.
- To gain an understanding of the relationships and interactions of (a) technology and societies, and (b) technology and individuals.
- To develop an understanding that technology, in itself, is neither good nor bad.

The curriculum design was very well done, but there was no apparent interest in an entire course in STS being taught in the public schools. There were no teachers prepared to teach such a course. Nor were there any support people or instructional materials for the course. That situation is changing, but it is likely that for a while, the greatest use of the STS will probably be infusion into classes of science, career education, technology education, social studies, and English and/or communications.

The Roles of Instructional Television

Television offered some unique advantages for implementing the YMT curriculum.

Role 1: Ease of Using Television in the Classroom: Television equipment is widely available in the schools for playback in the classroom as well as use of broadcast. More importantly, the teachers are familiar with its use in instruction, that is, the need for introductory and follow-up activities for the television lesson to provide a total learning experience.

Role 2: Preparation of Teachers: When television provides the presentation of content, experienced teachers can use the curriculum, or some part of it, without special or extensive preparation in the field of STS. Teachers are already experts in one subject matter area. As they learn with their students from the YMT programs and Teacher Guide, they will readily gain the knowledge needed to apply at least some aspects of STS in courses of their own specialty area.

Role 3: Visualization of STS Concepts: The capabilities of television to command attention and to place every student in the front seat for demonstrations are powerful instructional tools. Many of the concepts of STS are complex and abstract. By careful selection of examples, the television camera enables the students to see, both literally and figuratively, the concepts and their impact on our own lives.

The programs were specified to be 20 minutes in length to fit the typical 50-minute high school period. Each of the 12 topics of the curriculum is described in one program. To give teachers full flexibility in using the programs, they are complete in themselves and can be viewed in any sequence. For example, one teacher might choose to use only Program 4; a second teacher might use Programs 9, 2, and 5, in that order.

The formats of the programs vary to promote their individual use. For instance, some are documentaries, some have a host, and others are dramatizations. But none of them are lectures in the television studio. The programs are lively stories about the exciting topics of STS.

Role 4: Dissemination of the Curriculum: Television also provides a highly effective mechanism for dissemination of the curriculum through the well-established instructional television marketing systems for all schools K-12. The instructional television programs and the Teachers' Guide actually make up the curriculum. The Agency for Insturctional Technology (AIT) in Bloomington, Indiana is a non-profit educational organization. AIT's business is the marketing and distribution of instructional television programs and the supplementary print materials for public broadcast and audiovisual (classroom) use throughout the nation. In the past 20 years, AIT has built an excellent reputation among educators for reliability and quality in the dissemination of instructional programming.

Currently, the first five programs are completed and available from AIT for purchase or rental. There are four programs in production now, and the final three programs will be ready for dissemination in January, 1988.

Content of the Curriculum

A curriculum includes subject matter content, goals, and objectives for the students, teaching strategies, instructional materials, and readings. The curriculum designers were chosen for their

expertise in STS, regardless of any experience, or lack of it, in the public schools. They wrote the goals, objectives, and outline for subject matter content of the curriculum.

The 12 topics under which the content was outlined for teaching the 35 principles of STS, which were judged by the designers to be basic to understanding the field, are listed here in the recommended order for production of the programs.

- Living With Technology - consumerism
- Decisions, Decisions, Decisions - information processing
- The Technology Spiral - four revolutions in technology
- Energy and Societies - alternative sources for energy
- Health Technologies - social effects, costs, and benefits
- Feeding the World - agricultural technolgies
- Communications: The Expanding World
- The Fading Romance: Americans and Wheels
- China, Japan, and The West - transfer of technolgies among cultures
- Changing Technology and Population Patterns
- Exploring Space with Technology
- Risk and Safety with Technology

The designers suggested a storyline for developing the topics, but it was the educators who focused the teaching strategies, selected the most meaningful examples and approved the pacing of the programs to fit the needs and interests of the viewing students. They also considered the curriculums of science, technology education, social studies, and English/communications where the programs are very likely to be used for infusion.

Each program does represent a complete presentation of concepts and value considerations, but it is not a complete learning experience in itself. The *Teacher's Guide* is the mechanism for suggesting classroom activities to complete the learning experience for the objectives chosen by the individual teacher.

The roles of the *Teacher's Guide* are to provide the mechanism for preparing the students for the learning, for motivation and for clarification and applications of the learning. For each program, the *Teacher's Guide* provides.

1. An overview of the topic
2. A listing of the objectives as written by the designers for the subject matter of STS
3. A summary of the program storyline and content
4. Two suggestions to introduce the program, including any new objectives the teacher might choose to add
5. Follow-up activities for the program under the headings science, social studies, career education, and English/communications

The activities were suggested and developed by teachers from across the nation. Most of the activities require little preparation time and readily available materials and are very simple to do by an experienced classroom teacher. However, at least one major activity which develops thinking skills and which provides an opportunity for fairly extensive applications of the concepts taught is also included.

Instructional materials for use in introducing and/or following up the programs are also included in the *Guide*. Transparency masters were designed for, and with the assistance of, teachers. Each one could be used for 2-3 programs. The format is simple:

- concept to be taught in the upper lefthand corner
- graphic dominating the central area from which the concept can be introduced and developed
- question indicated in the space across the bottom to lead the discussion to the social effects or human values resulting from the concept

There is also a list of suggested readings for both the teachers and the students. And a list of additional sources of information relevant to the topics of the programs.

The design materials, the videotaped programs, and the *Teacher's Guide* do provide a complete curriculum for an introduction to the field of STS through the programs, the activities, and the transparency masters to support a curriculum of their own subject matter expertise. And it is apparent to the teachers that they are

teaching only one part of the whole field of STS, rather than thinking that any one of the topics is the field of STS.

Summary

You, Me, and Technology, through its use of instructional television is already bringing a curriculum of science, technology, and society into secondary school classrooms. And it is providing a realistic mechanism for use of STS topics in classrooms of career education and technology education. To assure its impact on those classes, the project will continue to rely on members of the International Technology Education Association and Industrial Arts Division of AVA. Their roles in the reviews of scripts, programs, and the teacher guide have been of great benefit in this first part of the implementation. The YMT staff looks forward to continuing this highly successful partnership.

♦♦♦

The writer wishes to achnowledge the generous contributions of expertise and energy to You, Me, and Technology by: The Designers: E. J. Piel (SUNY at Stony Brook), Leon Trilling (MIT), Richard O'Connor (Dutchess Community College), and Harold Cantor (Mohawk Valley Community College).

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Technological and Civic Literacy: Symbiotic Relationship

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Concern about the quality of American education has been characterized most recently by numerous responses by various committees and individuals. During the 1980's, more than fifty national reports have concluded that there is a crisis in American education. This response of educational reports, with demands for educational reform from the pre-school years through graduate school and beyond, has similarities to the post-Sputnik period. Now, as was the case after Sputnik, the United States' political and economic competitors are viewed as a threat by virtue of their scientific and technological strengths. Consequently, the call for "excellence" by many of the national reports have been linked to the upgrading of science and technology education in elementary and secondary schools.

The concerns expressed in the national reports have, additionally, raised the issue that students currently enrolled in elementary and secondary education, and those who will be enrolled in such education, will need a much different and more extensive science and technology education than that provided in the past. This issue may indeed have merit as one considers the many changes which have taken place during the last century.

The Importance of Science and Technology

During the past century advances in science and technology have altered the lifestyles and living patterns of most human beings. Nuclear power, space exploration, and medical advances in life support systems are only a few of the technologies that have impacted modern civilization. While optimistic viewpoints of the uses and further developments of science and technology can be found throughout the literature, there have been numerous reports which have focused on the "dismal" condition of the world as a result of their use. Two such reports; *The Limits of Growth*, and *The Global 2000 Report to the President*, conclude that the quality of human life on our planet is deteriorating, and many of the biological systems that provide resources for human needs are eroding. Noting these deteriorating conditions, political activists are calling attention to the need for a scientific and technological literate populace.

Public Attention to Technological Literacy

Since the late 1950's the topic of technological literacy has been brought to public attention by scientists, social scientists, and technologists. Many of these authors maintain that society has individuals suffering from "future schock," "technophobia," or "technological illiteracy" (e.g., Hellman, 1976; Hersh, 1983; and Toffler, 1970). Hellman (1976) and Toffler (1970) wrote that these individuals represent the illiterate sector of society; illiterate because they cannot cope with technological change.

Leaders in the field of education and government have also indicated that individuals within the United States are becoming a society of technological illiterates. Bowden (1982) noted: "We are poorly prepared to make the political, economic, and social decisions that science and technology present and impose on us" (p.5).

More recently, DeVore (1986) has expressed concern should society fail to evaluate technological change in terms of its costs and benefits, and the social change it may bring. DeVore wrote:

> Technological illiteracy will promote the demise of democracy and place in control an elite group of people who, by their knowledge and know-how, control the technical systems and who, by default, control the processes of public and private life. (p. 9)

Defining Technoligical Literacy

The outcome of the various national committees and commissions has been to focus on the issues of scientific and technoligical literacy. As in any reforming movement, there are important organizations. In this movement, the organizations are: The American Association for the Advancement of Science, the Association of American Colleges, the American Society for Engineering Education, the Congress of the United States, the National Science Foundation, a growing number of state departments of education, the Sloan Foundation in conjunction with college and university programs, and various national educational associations. Among the various associations and committees working to clairfy the meaning of the term technological literacy are idustrial arts/technology education (IA/TE), liberal arts (in the form of science, technology, and society programs), and science educators.

While these groups have expressed a need for a more technologically literate populace, Warnat (1983) noted that technological literacy had not been defined. Taffee and Keogh (1984) further concluded that there was a lack of consensus (p. 43) as to what the term means. The following definitions illustrate this point. Branscomb (1981) defined technological literacy as:

> The ability to understand and select from the vast catalog of technological abundance those tools and toys that best suit our own needs and interests - we need a minimum amount of competence to cope with automobiles, power saws, computer games . . . and microwave ovens. (p. 5)

The following definition by Dyrenfurth (1984) is different from Branscomb's. While Branscomb stated individuals need only a minimum competence with tools and machines, Dryrenfurth holds that individuals should have the necessary physical and mental capabilities to perform tasks using tools. Dryenfurth defines technological literacy as:

> The possession of a broad knowledge of technology together with the necessary attitudes and physical abilities to implement the knowledge in a safe, appropriate, efficient, and effective manner. Technological literacy requires that one be able to perform tasks using the tools, machines, materials and processes resulting from technology. (p. 32)

In another description, Shamos (1982) differs with Branscomb and Dyrenfurth in the concept of technological literacy. According to Shamos, technological literacy requires:

> very little abstract reasoning, and only a passing acquaintance with the conceptual framework of science. The primary objective should be to make one feel comfortable with his or her surrounding; not to regard the products of modern technology with awe or suspicion but to understand enough about their workings to have a sense of being in control. (p. 5-6)

While these definitions illustrate the variation in defining technological literacy, they do contain elements which appear to be universal in dealing with the term.

Toward a Definition of Technological Literacy

In order to understand what technological literacy represents, it may be helpful to offer a definition of technology. While there are many definitions of technology, the following is offered for purposes of discussion: Technology is the utilization of acquired knowledge, science, artifacts (tools and materials), and processes which humans employ to control their evolutionary process; as they attempt to solve the problems of society and those with which they come in contact. It is important also to consider the meaning to the term literacy. While the term has been used to describe various levels of knowledge, it is most often used to denote the ability to read and write at some minimal level. According to the American Heritage Dictionary of the English Language (1975), literacy is defined as "the ability to read and write" (p. 762). A secondary definition for literacy is "a well-informed educated person" (p. 762). Implicitly interwoven with reading and writing is comprehension.

Having made these basic premises, and after a review of literature dealing with the term technological literacy, a consensus might be reached on at least two, and possibly three general elements of the term technological literacy. The first two elements are: 1) technical structure and operation, and 2) a sociocultural understanding of the applications and limitations of technology. The third, and to some

extent a more controveraisl element, is the theoretical explanation of natural phenomena. A review of each of these elements will be discussed in turn.

Technical Structure and Operation

As recently reported by Miller (1986), a great number of people do not understand the inner workings of the major appliances and utilities that affect their lives (e.g., the automobile, electricity, and the telephone). While some consumers may have a greater depth of knowledge than others, it would seem reasonable to expect consumers to use these devices/systems in a safe efficient manner, and make redimentary diagnostic procedures in the event that the device/system should fail.

If one accepts this premise of what the ordinary person is expected to know about these applicances and utilities, then the same standard could be expected of an individual to other more complicated technologies. The education of the individual should include an understanding of tools and machines which are used as extensions of the human body, as well as the use of processes and systems in the manufacture of goods and services. Such an understanding might vary from the simple to the complex depending on the students' educational advancement.

Sociocultural Understanding of Technology

A sociocultural understanding of the applications and limitations of technology is perhaps at least as important as an understanding of its technical structure and operation. In examining this element, one could conclude that technology alone is not usually the solution to society's ills. In many cases, the major questions regarding technology are not technical, but human questions involving choices and values. It is these human questions that help to explore the ways in which technology can serve human purposes, and how it is affecting society. How technology is applied depends on what society thinks it is, what its limitations are perceived to be, what is its role in society, and how that role is assessed. These then should become issues addressed in a program which attempts to educate for technological literacy. Similar to technical structure and operation, understanding may vary from the concrete to the abstract depending on the students' educational advancement.

Theoretical Explanation of Natural Phenomena

While the literature whould appear to indicate that technical structure and operation, and sociocultural understanding of technology are recognized in a substantial number of discussions dealing with technological literacy, the third element (e.g., theoretical explanation of natural phenomena) does not maintain this acceptance. This element, however, can be traced to the original Snow (1959) lecture. In this lecture, Snow noted that contemporary society had been "polarized" into two separate and distinct cultures: "Literary individuals at one pole - at the other, scientists" (p. 4). Snow held that science brings humans together despite all the social barriers which could keep them apart. By speaking and working in scientific terms, the scientists of the West and the scientists of the East could communicate.

From this perspective, a further argument could be made for the understanding of science and the scientific inquiry process. If consumers are to make evaluations of the applications and limitations of technology, then it would seem appropriate that they would need to make observations of the technology, identify and describe various operations and techniques taking place, and possibly be involved in the decision-making process on whether or not to carry out potentially dangerous experiemental investigations. Clearly, such activities are already taking place by consumers in many of the biotechnologies, and are unmistakably directly related to science.

Having made these observations, and after taking note of the basic premises made of technology and literacy, these concepts could be applied to the term technological literacy to provide the following definition: Technological literacy is a multidimensional comprehension of technique and applied science, which are used to offer explanations and/or solutions the problems in the natural and human-made environment. While the purpose of this definition and outlined concepts were to bring about some consensus to the term technological literacy, it is clear to this researcher that more work is needed in this area. Several major questions that will have to be addressed are: Have all the dimensions to technological literacy been identified? What will be the depth and scope of technological literacy programs? How is it measured, and most importantly, who will implement these programs? These are questions which are being addressed by many state legislatures and governing boards of edu-

cation, and are questions which must also be resolved by the technology education profession.

Clearly, American society is based on the Jeffersonian principle that an informed citizenry is basic to a democracy. By being informed, citizens are in a better position to make decisions for its government. Yet, as public issues to technological problems require more technical expertise for their resolution, the gap between the experts and the public widens, and this could create the polarization which Snow warned. In the future, technological literacy in a contemporary society may be as neceaary as civic literacy.

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Technological Literacy Through Use of the Computerized Library

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Introduction

The acrhetype of Ashurbanipal's library (the first library) endures (Briscoe, Bodtke, Roberts, Douglas, Heinold, Koller, & Pierce, 1986). Libraries still collect, classify, conserve, and provide reference and access to information sources. While not severing the cord that binds them to the ancient archetype, librarians have abstracted their role, redefining it as that of information specialist with emphasis on access to information. It is now the collective library world, rather than the individual institution, that collects, classifies, and conserves information sources. The univerally acknowledged goal of libraries becomes the promotion of information literacy among the partrons they serve.

A working definintion of information literacy is "the ability to effectively access and evaluate information for a given need" (Breivik, 1985, p. 723). Our society is producing information in a myriad of media. The librarian, recast as information specialist, is daily witness to the fact that technological literacy, specifically computer literacy, is indeed an educational imperative. The response of the best and brightest librarians in a computerized library environment has been an updating of the concept of "the teaching library" (Rader, 1986) with librarians becoming technology educators.

The technologically sophisticated information sources presented to the user of the computerized library have two relations to technological literacy. The first is through the media itself and the second is through the message or content of these sources.

The Media

Online Catalogs: More and more libraries are presenting online public access catalogs to their patrons. These are by no means the first forays into automation for the many libraries who computerized circulation and exchange cataloging data and interlibrary loans via one of the vast computerized networks such as OCLC or RLIN (Research Libraries Information Network) which link thousands of libraries nationwide. However, much of this prior library automation was behind the scenes. It improved services and helped tool librarians for automation, but it did not alter the main routes along which patrons sought information. It is in their encounter with the online catalog that the majority of library patrons will be required to alter their information seeking behaviors (Jones, 1984).

In the online catalog patrons will come face to screen, fingertip to keyboard, with a computer terminal. The online catalog will introduce the user to an interactive system. Ideas of databases, files, records, command terms, and search strategies are concretely represented in the new catalog medium. The information seeker is introduced to the concepts of Boolean searching, browseable indexes and truncation of terms, and to notions of limiting and broadening search results. Comparison of catalog use shows that the subject search becomes paramount for all groups of users on the online catalog over the particular item search favored by sophisticated card catalog users.

If learning can be measured by an alteration in behavior, the online catalog is evidently teaching the users, and teaching them ways in which computers excel at information organization and retrieval. The positive image of the user friendly catalog can not help but enhance the user's belief in his ability to employ the computer as a tool. So strong is this effect that

when the online catalog crashes, users refuse to return to the card catalog (Jones, 1984).

Although some librarians follow the lead of well known librarian Michael Gorman (1984) in calling for "smart" terminals as front end processors interacting with the patron in a slow step-wise dialog requiring only natural language, others have shown that the online catalog user demands swift access to information and is willing to learn the requisite commands and structures of the system in order to meet that self-engendered demand (Markey, 1983). So librarians have mounted an instructional campaign to teach patrons how to use the computerized catalog. Librarians are in the enviable position of presenting computer systems in a non-coercive environment to those who come to them, to those who have a real need to know, which can be filled instantaneously by the application of a computer system. Quality online catalog instruction will give the patrons concepts and terms transportable to all databases.

The hardware and networking inherent in online catalogs are also eye-openers and thought-provokers for many users. The terminals and workstations of the online system will have good and bad features readily noted by users who, maybe for the first time, will be giving consideration to questions of ergonomics. Users invariably wish to know something of the system configuration supporting the computerized catalog. Librarians at Northwestern University explain their connection to the dedicated mainframe, while at Wichita State University the concept of time sharing on the university's mainframe is presented. The University of Wisconsin at Stout tours patrons through its minicomputer facility. The Los Angeles Public library and libraries across Kansas will soon be outlining the compact disc technology supporting their catalogs. Patrons may reflect on the advantages of distribution of information access as they use the terminals among the stacks or browse the academic library's catalog via a campus computing network terminal in their office or dormitory. Users are presented with the idea that they can dial into the library system from a personal computer.

Moreover, that mythical beast, the automated integrated library system, reported dead during the 1970's, has been observed alive again, at least in vague outline, in many libraries and in detail in the informed imaginations of librarians. This glorious creature will provide automation for all library functions, including the online catalog as its heart and primary organ of user interaction. The integrated system features one database recording all that the library owns and has on-order. The user of the integrated system will see information on a library's holdings down to the level of the individual journal issue and minute-by-minute circulation status. The resurrection of the integrated library system is due to a number of factors, including the maturation of systems design, specifically library systems design, and the decrease in the costs of computing power and mass storage.

At the university level, we hear about the phenomenon of increasing convergence of libraries and computing centers (Molholt, 1985) and of the library as nexus of the electronic campus (Van Horn, 1984). Indeed, at the University of New Mexico, the Dean of Libraries recently became vice-president of a new unit subsuming the library and the computing center. This unit is envisioned as the supplier and supporter of all information on campus. The library and the computing center often begin to see their natural affinity as microcomputer use spreads into libraries (see below) and across campus, and as computing centers look for large applications to keep their big computers busy. Hence the reemergence of the integrated library system. At any rate, there is no doubt that the operation of an online public access catalog or, even better, an integrated library system will enhance the computer literacy and confidence in dealing with technology among the ever increasing numbers of people who will be indoctrinated into their use.

Microcomputers: Automated integrated library systems may have the biggest impact on library users in the future, but the housing and use of microcomputers in libraries has attained epidemic proportions in the past few years. In 1980 microcomputers were found only in a few pioneering libraries. Now public and academic libraries, small and large, are offering patrons access to microcomputers. Almost every issue of every library periodical features one or more articles on the library microcomputer laboratory and its administration, the collecting and circulation of software by libraries, and the proper role of the librarian in microcomputer instruction.

What is the background and impetus for this micro-revolution in libraries? First of all it stems from patron need and demand as perceived by librarians -- librarians who have been tooled by their own behind the scenes automation efforts. Librarians can readily envision patron uses for the core personal computer

software packages of text processing, spreadsheets, and database management based on their application in library offices. Microcomputers are offered for patron use much in the same way that typewriters had been in a previous era of technology. At the Mann Library at Cornell University and at the University of Wisconsin at Parkside, you can find librarians providing workshops and answering questions about WordPerfect, dBase, Lotus 1-2-3, and a host of other general application packages. At the Wilmette, IL public library and at more than 20 other libraries around the country (Dewey, 1984) coin operated public micros were available for use. Systems are available free of charge in even a greater number of public library systems. Public library staff are also involved in educational efforts ranging from conducting general computer literacy courses to sponsoring local computer clubs.

The university libraries have been seen by university administrators as desirable and natural locations for microcomputer laboratories. When the colleges which the Mann Library at Cornell University serves determined to set up a microcomputer laboratory, the library, with its central location and long hours, seemed an ideal site. The administration of Texas A & M University answered the library's request for increased funding for audio-visual resources by bountifully funding a microcomputer laboratory. It was natural; libraries know how to organize collections of textual, microform, and audio-visual materials -- why not software? Moreover, the academic librarian is experienced in educating the user about tools applicable across academic disciplines. Academic librarians may actively seek the establishment of a library microcomputer laboratory, as was done at University of Wisconsin-Parkside and is being done at Pennsylvania State University.

Librarians often welcome the role of general computer educator. However, they still adhere to their univerally acknowledged role as fosterer of information literacy as distinct from computer literacy. Librarians may choose to use the microcomputers available to them to provide instruction in the manipulation of personal bibliographic files and in the organization of reprint collections. "Of course you can use WordStar here (at the library). There is a half-hour free between the Personal Bibiliographic Software demonstration and the SciMate workshop" (Jaffe, 1986 p. 29).

Often, a number of the microcomputers available at the library are reserved for end-user searching of remote online bibliographic databases or for searching similar databases stored locally on compact disc. The patron now searches independently for citations in the AfterDark or BRS remote databases or uses the CD-ROM systems of InfoTrac for general information and Disclosure for business information. Last year the patron had to consult the librarian who actually performed the online search. The only other alternative was to revert to paper indexes. But this year the patron is transformed into an independent searcher. But this transaction is not magical. Just as with the use of the online catalog, the information seeker's behavior must be modified through direct instruction and through practice. And in the course of learning the tools of information access, the information consumer's computer literacy is enhanced. Patrons are typically invigorated by the notion that they are linked to a mammoth computer in New York, or by the compactness of storage of massive amounts of data on the compact disc systems. Again, notions of databases and searching strategies familiar from computer literacy courses are imparted to the user in the course of an evening at the computerized library.

Librarians are also builders, collectors, and users of computerized information files. At Kansas State, we are building a file of campus resource persons and also a dBase file of our periodical holdings which will be searchable by keyword at the Reference Desk. Some libraries support collection and access of machine readable files by sizable budgets, refined collection development policies and, at the University of North Carolina at Chapel Hill, by the creation of a Machine Readable Data Files Unit. Publications such as *The County and City Databook, Directory of Public High Technology Corporations,* and *The Academic American Encyclopedia* are available in some libraries in machine readable form, allowing sophisticated full text searching.

Other Media

Libraries are involved in exploiting a host of other media besides online systems and microcomputers. Libraries are exploring applications of electronic imaging techniques, such as digitizing information on laser disc, in order to preserve deteriorating materials and to compress the storage of vast quantities of information. Libraries are using modern telefacsimilie for swift document delivery. Medical libraries offer all information in all manner of interactive systems, blending computer assisted instruction, video display and full text presentation.

Public libraries provide community information via videotex systems using local cable television or phone systems (Technology Committee, Public Library Associaiton, 1986). Some libraries sponsor electronic bulletin boards. Among library clients, who are the beneficiaries of such innovations in information access, there is often a byproduct -- an increase in the awareness of the possibilities of new technologies.

Microcomputers, Online Library Systems and Networks: The most significant impact of library related media will be the wedding of microcomputers, local online library systems, and large extra-library databases. Microcomputers will be the terminals of the online library system, both within the library and outside. Patrons will dial into the library system or will be linked to the library system via a local area network. The local library system will be a gateway into bibliographic and non-bibliographic databases maintained at remote locations on mainframe computers and into databases maintained locally on CD-ROM. Databases, including the library catalogs, will be augmented with abstracts. Citations and abstracts will be downloaded to microcomputers for manipulation and review. The user can input electronic messages requesting material or interlibrary loans or can send queries regarding the system or services. Making such a vision come true will require great strides in systems design and networking but also in the computer literacy of the information consumer.

The Message

Naturally the media described above are designed to have information content and that information content includes technological information. The user of the computerized library should have an easier time accessing and manipulating technical information and information on technology.

The seeker of technical information may find a host of citations on the impact of the computer on society by searching AfterDark online or by using the InfoTrac compact disc system. The user may be able to search the combination the terms "computer" and "civilization" in the local online library system, deriving the call numbers and circulation statuses of appropriate books, periodicals, government documents, audio-visual materials and machine readable data files.

Eventually the user will be able to gain access to the holdings of the region and to the nation's holdings on technology related topics. The former will be realized by gateways into state and regional joint catalogs, and the latter by the development of subject searching of the great national bibliographic systems and their linking. OCLC, the system which links over 6000 libraries across the nation, has a major project underway which will allow subject access to the over thirteen million bibliographic records in its database. You can expect to see OCLC make many more OCLC terminals available for searching by patrons in the next few years. Meanwhile OCLC is linking itself to the other major library networks, RLIN and the Western Library Network. This will be one of the largest computer networks in the country. Eventually the seeker of information, technological or otherwise, will be able to download citations from the local catalog, from the national catalog and from databases covering periodical articles and technical reports. The user will have the software and storage required to manipulate the downloaded information. This is the so-called scholar's workstation. There will also be access to statistical and other non-bibliographic databases. In the more distant future, the user will derive the full text of the certain high demand sources. The determination to include full text will be related to perceived use and to economics.

Librarians envision themselves as intermediaries in the process of automated information access. Perhaps we will travel within our communities, schools, or campuses, instructing clients in the use of the computerized systems. Others of us will be busy evaluating information sources for inclusion in the full text databank or in classifying, abstracting, and indexing information sources. Librarians will also be helping to design better information access systems.

Conclusion

Libraries and librarians are participating in the advancement of technological literacy by providing access to computerized information technolgies. To an ever growing degree, technological literacy is being enhanced not only by ready access to actual technical information in the computerized library environment, but also as a byproduct of required patron use of the automated information systems.

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Mathematics: The Misunderstood Language of High Technology

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In 1986, the field of industrial arts/technology education stands at an important intersection. The direction in which the field turns will have much more impact than a simple name change. Our professional organizations are changing their names to reflect technology education, and so are many programs. There are many scoffers who claim that nothing will change except the sign over the door, but there are others who are much dedicated to an effort to reflect something called "technology" in our courses and curricula. This group of professionals includes leaders of considerable talent and influence.

The "technology" which is the general target of our efforts has several characteristics: First, it is a moving target which will always slip further into the distance as we approach it. This does not in any way lessen the importance of our aiming at it--it merely heightens the challenge a good bit. Second, the target is somewhat different than the one which would have been described in articles and books of twenty years ago by the word technology. This new (or, should we say, revised) target has a very clear connotation of "high" technology, complete with computers, robots, interfacing, cybernation, and a wealth of related jargon and concepts. Again, this is not to even infer that the older denotations and connotations of the word "technology" were wrong, or even that they are invalid today. It is merely to call attention to the very real changes at hand. Thirdly, there is some degree of disagreement among our leaders and other professionals concerning the exact aspect of this [high] technology which we should study and how it is to be implemented in times of declining student population and decreased financial support. Even this minor discord, though, is acceptable and healthy for our profession if only to keep our best minds seeking new answers and higher truths. These assertions can be supported and further explained by the opening series of articles in *Implementing Technology Education* (the 35th ACIATE Yearbook), especially the articles by Lauda and McCrory (1986), Peterson (1986), Bame (1986), and Helsel and Jones (1986). Lastly, however, the move to technology education must result in greater emphasis and dependence on mathematics.

This paper deals with the manner in which mathematics should be used and treated in the new technology education laboratory. It discusses research which is currently in progress and introduces new curriculum materials presently being published that approach the mathematics of technology in a manner which might be more appropriate for technology education students.

Traditional Methods

One large challenge of the new technology education will be to decide which of the traditional topics, practices, and methods are still appropriate and which need to be abandoned or curtailed. The process will invoke considerable concern and some degree of real pain for many professionals who feel that they have been providing good programs for some time and see little need for sweeping changes. Many sacred cows may be slaughtered as we approach high technology. Of concern here are those teaching methods used in the handling of mathematical concepts.

Mathematics is very much a part of high technology--indeed, it is a large part of any technology. Therefore, our curricula must reflect some degree of attention to mathematics. Likewise, our teachers must be able to teach and our students able to learn mathematics. The importance of mathematics for technology

education (and vice versa) should be self evident, but it is unfortunate that the 31st ACIATE Yearbook: *The Contributions of Industrial Arts to Selected Areas of Education* (Maley & Starkweather, 1982) makes little mention of mathematics other than a few references to "arithmetic". Especially in courses dealing with communication technology, and power and transportation technology, mathematics is actually the basis of much of the content which is studied. It is in these courses that effective methods of handling mathematics is most essential.

The traditional methods which have been used in industrial arts/technology education courses (especially, but not limited to, electronics and related courses) have not been every effective for many students. The traditional approach will be referred to as the "engineering school model" (Haynie, 1986) hereafter. In the engineering school model, the concepts of study are presented and explained in whole or in part by means of mathematical formulas and problems. A typical scenario is as follows:

> The students read (or fail to read) the assigned chapter on Ohm's Law in their textbooks. The chapter is as long as twenty or so pages and it contains (typically) Watt's Law, series and parallel circuits, and Kirchoff's Laws as well. It is one of the earliest chapters in the book. The teacher then either gives one or two long lessons to cover the entire chapter, or divides the lessons into smaller bits which appear fragmented in relation to the textbook chapter. The concepts concerning the crucial relationship between voltage, current, and resistance are presented mainly in terms of various formulas for Ohm's and Watt's Laws--as if merely seeing the formula: $I = E/R$ will "naturally" produce an understanding in the students' minds that the current will increase with increasing voltage and decrease with increasing resistance.

Contrived as it may seem, the above is a fairly accurate description of the handling of one of the most important relationships in electronics. The engineering school model can only succeed in teaching these topics if students are fluent in the language of mathematics. This is because mathematics is the language upon which this method relies to deliver the instruction. Students must be fluent in the language of instruction or effective communication is not possible.

Still another flaw with the engineering school model is that it leaves students confused as to what is most important to learn about the topic at hand. They do not really understand the concepts or relationships which were presented mathematically, but they readily see that the formulas appear to be important. So, they memorize the formulas and try to apply them in a rudimentary manner. Benjamin, McKeachie, Lin, and Holinger (1981) found that many students who claim to be test anxious actually study as much as or more than their peers, but they choose to study the wrong things. The engineering school approach could be particularly harmful for these students because it *seems* to stress some of the least important facets of the topics under study.

Changing Clientele

It would be the hope of all who are keenly interested in the move toward [high] technology education that the new courses and topics of study would make our programs more attractive to a wider range of students-especially the upper level and college bound students. This emphasis is clearly evident in the work of Daiber and LaClair (1986) in which they discuss the flexible curricula needed to serve a varied student population.

There are, however, three factors which work against our efforts to attract more upper level students. The first of these is the decline in the school age population in general. The second factor is that many states and localities are assuming a back to basics posture with regard to schooling for all students--especially the college bound. This results in students having fewer free electives in their programs and little support from parents and guidance counselors to choose technology education courses. The last, and possibly most damaging factor of all is that the first few years of the new technology education effort will be carefully scrutinized by all interested parties. If, during these trial years, we do not "get our act together" and really do some new and different things in our programs, they will be viewed very skeptically. This is particularly dangerous since those among our ranks who choose to resist the change can be very visible. These factors will combine to make it very unlikely that the average ability level of technology education students (as a group) will increase significantly in the next few years. If anything, it is possible that the ability level will decrease slightly (unless large numbers of low ability students who desire to take a "shop" course are frightened away by the new high tech image). Perhaps, after several successful trial years, the hopes of those who long for the opportunity to teach higher ability groups will be realized, but for the present we must be equipped and willing to handle our

present student population--including its large percentage of lower ability students.

Teaching and the Language of Mathematics

Mathematics is a language (of sorts) which is complete with its own alphabet (symbols), grammar and syntax (rules and conventions), and stories to tell (logic and relationships). When students from foreign countries come to the United States, we offer them special English as a Second Language (ESL) programs which prepare them to benefit from instruction in their other courses because that instruction will be delivered in a language other than their native one. If technology education is to succeed, we must either provide "MSL" (Math as a Second Language) courses as prerequisites or insure that the initial instruction on each topic is in the native language of our student--and that native language is not mathematics!

Since we can no longer depend upon mathematics to be the vehicle (language) for instruction in our technology education courses, as in the engineering school model, we must determine the right relationship between mathematics and our programs. It would be unforgivable to ignore math. We must reinforce and teach mathematics and the other basics in all of our courses (Haynie, 1985). This author has done considerable informal and pilot research on how math is handled in technology education courses (especially electronics). Further, more precise and formal research is currently in progress, but preliminary findings are that the engineering school model is most often used in curriculum materials and frequently by teachers. Additionally, many teachers report that the ability level of their students is lower each year and their mathematics ability is particularly of concern. Frustration among electronics teachers who hope to reflect higher technology but find their students unable to even understand Ohm's Law is widespread. There is even pressure from some camps to curtail programs in answer to the back to basics cry and to save scarce resources (Gray, 1982; Haynie, 1985; Raferty, 1982; and Sewall, 1982).

Some teachers answer these challenges by retreating; by avoiding the mathematics topics and teaching from a purely conceptual approach which does not require any attention to math. This is a form of neglect which provides viable evidence for those in the back to basics camp who would do away with industrial arts (by any name) and other elective subjects they call "frills" (Haynie, 1985). Another approach which is far too frequently used to continue with the engineering school approach and merely fail or socially promote the students who are less able to handle the math. These are all unacceptable options.

A Better Approach to Mathematics

The approach which has found greatest success (and which is used in the soon to be published electricity/electronics textbook by this author) is to teach each concept without any reference to mathematics at all and then cycle back to use the students' newly acquired knowledge of the concept as a tool to teach the related math (Haynie, 1986). The concepts must be presented very clearly and with some repetition--enough to insure that students clearly understand them and feel comfortable with them. After each concept has been taught, learned, and "chewed-on" for a few days, the math is presented. Topics must be divided into smaller, bite-sized chunks instead of the traditional ten to twelve chapters per year. This author's textbook has 65 short "Readings" designed for 2 to 3 day coverage. An important topic like Ohm's Law is presented in a series of several readings:

- First, the concepts are learned without any math or quantification of values. The relationship is stressed.
- Next, the methods of quantifying are covered, and the relationship is reviewed (repetition helps the student to possess the new terms and concepts as his own).
- Then, the basic formula for Ohm's Law is presented and very simple problems (*all* with values which can be solved "in your head") are used to illustrate how to work the formula. The way in which the formula represents the previously learned relationship is stressed here too.
- Only in the last Reading of the sequence are more difficult problems with realistic circuit values presented. Here students are taught how to properly use logic along with their calculators--instead of merely trusting that whatever response appears on the readout will "automatically" be the correct answer.

The whole sequence requires from six to ten class days, which provides many opportunities for reinforcement and repetition. Associated laboratory experiments from the lab manual accompany each Reading and follow the exact

same sequence: progressing from simple to complex and building on previously learned information. The text and teacher's guide also provide helpful tips for teaching the mathematics skills needed for each topic. The approach has been successful with students from eighth grade through college undergraduates--though the sequence is generally speeded up considerably for the more mature students.

Conclusion

The move toward technology education will necessitate that teachers be more able than ever before to teach mathematics in conjunction with their courses. The traditional engineering school model is not effective with our present students and there is little likelihood that student ability levels in mathematics will increase significantly for the next several years. Preliminary work has shown that even lower ability students can learn the mathematics skills and processes needed for success in technology education classes if they are presented by the methods advocated here. Teachers must teach math through concepts instead of concepts through math if they are to achieve defensible goals for the new technology education with their students.

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Integrating the Systems of Technology

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The Overview

An understanding of "Integrating the Systems" will provide you with the flexibility to teach about and facilitate student's learning about technology, not just the individual segments or parts that make up technology. Integrating the systems is an approach to incorporating teaching methods, unique ideas, and new curriculum information into your classes. This can be accomplished easily and naturally while implementing the study of technology.

It is unique that "integrating the systems" is apparently the only technique or approach available to the teacher that provides a means for students to truly learn about technology as an entity, as a whole, as a discipline, as technology education. As DeVore (1980) stated, "The study of technology has been approached too frequently by studying the parts without reference to the whole" (p. 243). Actually, while teachers utilize the integration approach as a natural part of their teaching about technology, they typically do not consciously realize it is happening. The purpose of this paper is to help bring about that realization.

The Situation

Technology education is the study of the technological systems including construction, manufacturing, transportation, and communication (Hales and Synder, 1981; Ray, 1980; Starkweather, 1983; American Industrial, 1985; Jones & Wright, 1986). It is these four systems that humans have used to survive, to adapt, to make their way through history, and to become relatively comfortable and safe in this, the 20th century. It is through the study of these systems that we will encourage and help young people to become more knowledgeable consumers, better questioners of political and ethical values, and help them to become technologically literate so they may challenge the 21st century, a mere 14 years from now.

The Method

The systems approach to the study of technology provides a convenient organizer for developing curriculum in technology education (Bensen, 1980). The systems model includes input, process, output, and feedback and provides a simple and efficient means for planning and presenting information in an effective manner (Illinois State Board, 1983). Studying technology via the systems model will enable students to grasp technological concepts in an effective manner, thus helping to ensure an increase in technological literacy (Jones, 1983).

An easy method to organize and study technology is to apply the technological systems of construction, manufacturing, transportation, and communication into a general systems model. The results are as follows:

Input....becomes....Resources

Processes....becomes....Technical Processes

Output....becomes....Industrial Application

Feedback....becomes....Technological Impact

An understanding of the four levels or parts of the system and their interrelationships is, in fact, an understanding of the total system. An understanding of the total system is the attainment of the goal, technological literacy. Wright (1980) cited that one of our primary goals should be the development of a "technologically literate" individual. To illustrate this, let's expand on the four parts of the technological systems model using communication as as example.

Resources are tools and materials. In communication they include such things as a camera in photography, a printing press in printing, a drafting table or computer for design area, or a video cassette recorder in the telecommunication area. These examples are resources, but they are all tools, i.e., some type of equipment. Other resources used in communication include materials such as film, paper, cassette tape, ink, and chemistry to name a few.

Technical processes is the act of using tools to change or modify materials in some manner. Industry uses a variety of processes through a planned sequence and produces some type of service or product. We use a camera to expose film to light as one of the technical processes in communication. That, in effect, changes or modifies the film. The technical process of exposure starts a chemical reaction in the film's light sensitive emulsion. The next step is to initiate another process by placing the film in a series of chemicals to develop or "process" the film to produce negatives, or positives in the case of color slides.

When we study *industrial application*, we actually consider it from "outside" the model. When we are talking about the communication systems model, we look at how communication is applied with the other systems. For example, how is communication used in construction, how is communication used in manufacturing, and how is communication used in transportation?

The *technological impact* part of the model is how society or the environment is impacted by, in our example, communication. Technological impacts are easily studies as either societal (those that affect people) or environmental (those that affect the environment). Technological impacts are either negative, positive, or both. In one situation, an impact may be negative such as having several drafters lose their jobs by being replaced with one computer-aided design (CAD) operator. Impacts may also be positive such as having those same drafters retrained to become CAD operators.

The Problem

Many schools are starting to offer courses in, for example, communication or manufacturing. But, are these technological systems totally independent? The answer, of course, is "No!" If not, where do we "bring it all together," where do we deal with integrating the systems of technology, and where do students grasp an understanding of *technology*, not only the subsystems? Where do students have the opportunity to truly increase their technological literacy through an understanding of technology?

The Dilemma

Technology education may be following the tradition of industrial arts, that is, in attempting to totally separate and teach the systems. In industrial arts, it was generally assumed that students would understand "industry" by taking courses in woods, metals, electricity, etc, but that understanding of industry simply did not happen. Through curriculum research such as the IACP, Maryland Plan, and American Industry Plan to name a few, efforts were focused on bringing that "industrial information" back into the curriculum. Is technology education also assuming an understanding of technology by focusing on the individual systems? If so, a similar dilemma may emerge.

The Solution

Let's look at integrating the systems, or, how they are all pulled together. For example, did you realize that it is virtually impossible to teach manufacturing without teaching transportation, construction, and communication? You can teach parts of manufacturing, but if you teach manufacturing as a total concept, i.e., the enterprise, you must include the other three systems. You are probably including them now and may not realize it. Consider the following examples.

Manufacturing and Communication: Consider communication as it relates to manufacturing. When you teach manufacturing, do you talk about brainstorming, product design, sketching, designing a totally new product, or maybe redesigning a "new and improved" product such as a frisbee? The idea of design is simply putting abstract ideas into a usable form that can be communicated to others. One of the first forms is a sketch. Sketching is a communication process, not a manufacturing process, but is it absolutely necessary as part of the total manufacturing concept.

Do you have a marketing group? Are your students doing marketing surveys? Are they advertising on radio and television? Are they considering the development of posters, static or dynamic displays, or newspaper advertising? These are communication "things". Yes, you

must use many aspects of communication if you are really going to teach manufacturing.

Manufacturing and Transportation: How do you teach transportation as a part of your manufacturing course? Do you discuss how the rough stock gets from the supplier to your school? It doesn't magically grow in your storeroom as some students may think. Do your students study this information as part of your manufacturing course?

How do you move the rough stock from storage to the first machine? Do you use a conveyor system? Do you carry it? Have you considered how to move the various parts during the production run? These are real material handling problems that must be solved in the transportation portion of your manufacturing course.

Manufacturing and Construction: What about construction? How, or even better, why would you deal with construction if you were teaching manufacturing? Consider this: Don't real manufacturing companies have to design facilities?

There is construction information significant to many manufacturing processes. What about the safety considerations related to the building? Do your students study about traffic flow and safety lanes in machine areas? What about lighting, heating, ventilation, and getting rid of saw dust? Aren't these really construction problems? You should deal with those when you teach manufacturing since they are all important considerations. Industry deals with them and you should too.

A Natural Integration

Strangely enough, your problem is not trying to mesh the technological systems so they will work together. This is a natural working, natural integration of systems that will apply to virtually anything humans do or have done. We can take any one of the systems and with some simple brainstorming, easily see how the other three systems fit in. Consider the computer-aided design of the space shuttle to the special construction techniques needed to house that space shuttle to the manufacturing problems needed to produce special ceramic tiles to protect the nose cone; the systems worked together naturally, easily, and the result was a transportation vehicle.

As a future technology education teacher, my recommendation to you is this: Don't try to separate the systems. It is nearly impossible. It is impossible. It is impossible because it is extremely frustrating and you will find yourself trying to segment or compartmentalize the systems. They really can't be taught that way.

Integrate the systems. When your manufacturing course deals with communication ideas, study them as communication ideas. Make it known that these things work together in a natural way. When dealing with moving goods, call it transportation systems. When designing your manufacturing facility, call it construction. It's OK to do that and it's OK to do that within the manufacturing course. The same holds true if your are teaching any of the systems.

Some Random Thoughts

It's interesting that throughout technology education, one of the major goals has been to increase levels of technological literacy in students. Literature citations alone that verify this would fill many, many pages. It's equally interesting that our focus, curriculum efforts, promotion, research, teaching, workshops, symposia, conferences, articles, etc. have typically concentrated on the development of the individual systems of construction, manufacturing, transportation, and communication among others.

But, where is it written that we need future leaders who are "manufacturing literate" or "communication literate?" Of course "manufacturing literacy" is not a goal but how does one attain technological literacy by studying manufacturing? Simply, one does not. Technological literacy is attained by studying technology.

Then, let's consider technology. Think of technology as science getting down to business or it's when we put science to work for us. It's when we use the discoveries in science to better our lives in many ways. It is how we manufacture goods, it is how we construct shelters, transport ourselves or other goods, and how we communicate. It is these "things" that make up technology. These are technological systems.

Technology education, then, is the study of technology through the technological systems. The four systems that humans have used to survive, to adapt, to make their way through history and to become relatively comfortable and safe in this the 20th century.

We must study technology to attain technological literacy. An easy method of studying technology is through the systems. Yes, you can study technology in a manufacturing class since the systems are naturally integrated. However, all of us must make a concentrated effort to focus on technology, not just the individual system. We must not concentrate on individual systems and illustrate them as stand alone systems; they are not. To propose them as stand alone, or separate systems with no connections will lead educators into the same pitfalls as industrial arts. There, we often proposed that for students to complete a woods or metals course would provide them with knowledge and an understanding of industry. It simply didn't happen.

Conclusion

Integrating the systems is the natural process of teaching technology education. It does not require special preparation on the part of the teacher, it is already there, neatly tucked into all technology-based curriculum.

Teachers should take advantage of the natural integration of the systems to help plan more diverse content, to "turn students on" to the study of technology, to get them involved and working on technological problems, and to simply have a better, more interesting class. Consistently, teachers should keep the ultimate goal in mind: Increasing technological literacy. That goal is more easily reached through integrating the systems of technology into the day-to-day classroom and laboratory activities and information.

Technology education has proven to be the opportunity for industrial arts to survive in a different form. However, it was and still is a challenge and a positive opportunity to maintain a technical type of program in the general education of students. In addition to technical skills, students need to develop thinking skills, and they need problem solving skills as well. Students will need skills such as these to become technologically literate and to become the survivors and the leaders in the 21st century.

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Technological Literacy: An Educational Challenge

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The term "technological literacy" has been occurring in the printed media with increased frequency. The popular press has reported the findings of research studies on the subject (Miller, 1986; Rothman, 1986). The International Technology Education Association has identified it as a major goal of the discipline. Several scholars in the field have written about this phenomenon (Dyrenfurth, 1984; Lemons, 1984). And Symposium VIII has been dedicated to this topic. So the reader will readily discover that many of the ideas expressed in this article have already appeared in print. However, a topic of this importance is deserving of continued dialogue.

The definition of technological literacy is somewhat illusive. One reason for this is that the concepts embodied by the terms "Technological" and "literacy" are dynamic. They are clearly dependent on the evolutionary nature of society. Let's look at the concept of literacy. When society was predominantly agrarian, literacy simply meant the ability to read, write, and count. Most people could achieve this ability with several years of formal schooling. However, as society became more urban, the need for greater competence in reading, writing, and computing increased. Thus, more formal schooling was required. Now literacy includes the competence to locate, sort, analyze, and synthesize an enormous amount of information (Hersh, May, 1983).

Technology, on the other hand, is defined as "...practices in order to test or refine theories of efficient action, which can only be derived from practice. Knowledge (ology) of practice (techn) is technology" (Lux, 1983). This definition clearly implies that person(s) are a significant element of technology. Thus, there is a "societal" context. And, of course, the practices referred to are continually undergoing constant change. In a similar vein, the concept of "technological" originates from the definition of technology. It follows then, that a combination of the defnitions "literacy" and "technology" provides the following description of technological literacy: the competency to locate, sort, analyze and synthesize information that relates to achieving practical purposes through efficient action. To add clarity to this concept, a review of the nature of technology is in order.

The Nature of Technology

Technology extends human potential. Over time, humans have learned to develop tools, machines, and techniques that aid in the achievement of their goals. Initially, relatively simple applications of levers, wheels, and inclined planes were integrated into machines. Currently, however, the more visible mechanical technologies are being integrated with the more abstract pneumatic, hydraulic and electronic technologies. Those who understand and use these technologies have unbelievable potential and are now sometimes referred to as "technocrats."

Think for a moment of the capabilities available to humans. Instant world-wide communication via satellites. Rapid land, air, and space travel. Automated manufacturing systems. Technology has made all of this possible and now perhaps more emphasis should be devoted to questions like "What message is worthy of being communicated? Where and why should we go? and, What items should be produced?" Too much attention is given to the development and use of these technologies and too little to their appropriate applications.

Technology fosters ignorance, dependance, and even procrastination. It seems to be the goal of technology to make devices that can be used with little or no understanding. For example,

computer programs are made to be "user friendly." Automobiles are most often driven by people who are unable to explain an engine's operation. We use microwave ovens, calculators, telephones, computers, digital watches, automatic bank cards, etc., and have limited understanding as to how they operate. We become so dependent on these devices that we cannot carry on the day to day operations when they malfunction.

Technology has an impact on social institutions. The more equitable position of women in society can, in part, be attributed to technology. According to Peter Drucker, the telephone and typewriter had a strong positive impact on the social position of women. These devices made it possible for women to make a respectable living on their own. The need for their services caused a need for more education which was an important factor in obtaining the right to vote. And now, we find women in almost every occupation. In a similar vein, technology has provided many handicapped persons with the means for becoming independent contributors to society.

Technology changes the work place. Electronic mail, word processing, data processing, sophisticated communication systems, and other automated devices continue to alter the nature of work. In some companies, technology changes so rapidly that the managers have to be located close to the innovators so they have at least a conceptual understanding of the evolution of the products they are producing. Managers can now have access to a great deal more information from a centralized data base. This makes it possible to monitor an organization far more closely and thus, cause it to operate more efficiently.

Technology changes the nature of warfare. War has always been cruel and destructive. Nevertheless, politicians and military leaders have used this institution of society to impose their will on given populations. In many circles, war is considered a rational tool of policy. Technology has altered this situation. With the advent of nuclear energy, total war ceases to be a usable institution of human society because in all our modern technological warfare, there is no victory. There is only total destruction. No one can escape this destruction because they are "neutral" or "noncombatant;" the destruction can extend to the entire human race (Drucker, 1967).

Technology transcends national boundaries. Due to efficient transportation and communication systems, nations are becoming more and more interdependent. American companies are building manufacturing facilities in other countries. Other countries are building factories in this country. Many items have components made in several countries. Thus, the entire world population becomes a potential workforce and buyers of the goods produced.

We can certainly see that the nature of technology is far more than just a study of practices or of technical information. It includes the societal, cultural ramifications. To extend human potential without this consideration is extremely risky. Perhaps it is the role of technolgy education to add the societal and/or cultural dimension to the more "technical" aspect of the curriculum. In this way, students may become more "technologically literate."

At this point a description of some of the characteristics of a technologically literate person may be helpful. First of all, this person should be able to utilize the appropriate technology in the context of the societal situation. On the personal level, sometimes a pencil and paper are adequate for recording our ideas. We don't always have to have a word processor at our finger tips in order to record our thoughts. On a larger scale, it would be inappropriate to introduce highly mechanized farming techniques into a society that is heavily dependent on labor-intensive procedures. Questions such as, "What should displaced workers do it they are no longer needed? Who will repair the new technology when it is implemented?" are important considerations. They should be addressed prior to implementation.

Second, a technologically literate person must be able to predict the societal and/or environmental impact or result of using a given technology. We have little evidence that anyone questioned the impact a large number of cars would have on the quality of the air that we breathe when they were introduced into our society. We now know about air pollution and called upon technology to provide emission control systems. You can see from this illustration that technology is often relied upon to solve problems that technology has created.

Third, the technologically literate person must be able to identify alternate technologies which could be utilized in the event of a malfunction in the technology commonly used. In many instances, we have become so dependent on a given technology that productivity ceases when that technology fails. Nowadays, large organizations have been known to come to a virtual

halt when the computer breaks down. Or, most persons are so totally dependent on a personal automobile, they find it difficult sometimes to even think of alternate modes of travel, let alone utilize such.

Fourth, a technologically literate person should be able to understand and use the basic mechanical, thermal, fluidic, and electronic principles incorporated in the devices that extend human potential. When the refrigerator or the microwave or the air conditioner or the furnace or the car or the computer does not perform as expected, the technologically literate person should be able to analyze the situation and determine whether or not, in fact, an expert technician is needed. Quite often, the malfunction is related to some very simple solution. For example, a repairman charges the $45 minimum to fix the air conditioner, even if it is only to switch the circuit breaker or replace a fuse. In this case, the solution to the problem is one that the technologically literate person should have arrived at for him or herself.

Fifth, the technologically literate person should be able to gather and interpret data. One aspect of this includes the ability to access computerized data bases to retrieve information on any subject. The other involves the skill of using instruments to monitor the operation and performance of technological devices. This skill will help the user to isolate the subsystem or component that is in need for adjustment, repair or replacement. Even if the device is so complex a specialized technician is needed, the user will have the satisfaction that the problem was dealt with efficiently and satisfactorily.

And finally, the technologically literate person should be able to use the basic tools, materials, and processes of technology. Currently, without question, the most basic tool is the computer. One must be able to utilize this tool in a wide variety of situations. An understanding of its limitations is also important. There are, of course, many machines (simple and complex) that separate, form, and combine materials. Having the competence to use these devices adds to one's technological literacy. Similarly, knowledge of the characteristics and applications of common materials such as plastics, ceramics, metals, and composites is also beneficial. Then an appropriate material can be selected for a given situation.

Six characteristics of a technologically literate person have just been described. Do students who have taken technology education classes exhibit these qualities? The new curricula currently emerging in many states does have the potential for achieving this goal. The new coalition between science and technolgy also has potential. The need for increasing the technological literacy of our citizenry is unquestioned. The real issue is: How and who shall do it? Technology education has the opportunity to have a role in achieving this goal. Let us hope those in the discipline are ready to accept the challenge!

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OM: College/University Creative Problem Solving Competition

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Background

As an integral part of the Industrial Design and Expression through Materials courses offered by the Department of Technology at Glassboro State College, creative problem solving activities are given to help broaden the students' awareness and increase their sensitivity to creative thinking. From these courses, which are challenging, fun, and inexpensive, an international program has blossomed. The name of the program is OM. It was originally called the "Olympics of the Mind."

The OM Program has proven successful when used to stimulate and develop students' creative problem-solving abilities. The OM activities have assisted elementary and secondary teachers in building skills and knowledge by providing challenging and interesting problems for students to solve. Students have the opportunity to test their solutions against those solutions developed by students in other schools. The competition between schools generally begins at local levels and culminates in an annual World Finals competition.

Crestive Problem Solving

Creative problem solving is the essence of the OM competitions. Basically there are two types of problems. Convergent problems are analytic, that is, they have one correct answer. Divergent problems, on the other hand, have many solutions or answers. Examples of convergent problems might be:

1. Who wrote *Julius Ceasar*? The single correct answer is William Shakespeare.
2. How many revolutions will a 14" wheel make when traveling one mile? Although poorly stated, this problem seems to imply that there is a single correct answer.

Sometimes the creative individuals see other possible answers in convergent problems. This could indicate one reason they often have trouble with standardized tests. A science teacher once presented a lesson in barometric pressure and how it changes at various altitudes. The teacher asked, "Using the barometer, how would you determine the height of a skyscraper?" Perhaps expecting the students to apply a given formula, the teacher was faced with a number of unusual responses including, "Tying a string to the barometer, lowering it from the roof, and then measuring the string." Was this student wrong? Another said, "Drop it from the roof and time the drop." Since all things fall at the same speed, the height could be determined. Was he wrong? Another said that she, "would use it as a door knocker, then ask the building superintendent how high the building is." Was she wrong? These students tried to solve the problem in unique ways. They did not assume they had to use the barometer in ways that may have just been implied.

Divergent problems are those which have many solutions. For example, designing an appliance or an automobile is a divergent problem because there are so many variations to the solutions. Subjects which encourage unusual thinking are generally preferred by highly creative individuals... Incidently, some may answer "0" to the wheel revolution problem asked earlier, if it was a spare tire, a tire on an airplane, or one vehicle being carried by another. The revolutions may also be increased if the wheel was spinning in the snow or mud.

A good Creative Problem Solving format is: (a) statement of the problem; (b) ideation (with suspended judgement); (c) judgement and/or

evaluation; (d) carry out the problem solution; and (e) elaboration of the solution.

The statement of a problem is perhaps the most important part of encouraging an individual to think. Let's look at a problem that is stated poorly and revise it in order to help stimulate original thinking. Poorly stated: "Design a boat to cross a small pond." This problem is stated poorly because it encourages a stereotypic solution. Most of us have a preconceived idea or concept of what a boat is and its general form. The chances are that individuals would make a boat pointed at one end, a place to sit, and some sort of paddle for propulsion. In order to encourage students to think, problems should be stated in broad enough terms to avoid stereotypic solutions. Include some limitations to assist the students in formulating a variety of solutions. Consider the following alternative statement of the problem: "Design a device which will transport one individual across a pond." The following limitations might then be imposed:

1. No internal combustion engines may be used for propulsion.

2. A maximum of $5.00 may be spent. Discarded materials which do not count toward the $5.00 limit can be collected and used.

3. Three weeks may be taken to complete the project.

4. The device must keep the user safe and dry.

5. The device must be able to be navigated over a given course.

By stating the problem in broad terms we can transcend the common concept of "boat." This opens one's imagination to walking across the lake; to using "hamster-cage" designs to spin across; to use a 12-volt battery to power crafts, (although no internal combustion engines were allowed, electric motors were); to floating a trash can; etc.

When generating ideas, remember one primary rule: Don't judge ideas too soon. Establish a positive attitude; make your colleagues, students, or team members want to make it work. Ask continually, "Is there a better way to do it"? Idea evalution takes place after a number of possible or impossible solutions are mentioned. Next carry out the solution. The best ideas are not good if we do not follow through. At this point one may revise and/or elaborate on the solution. The device may be painted, have a comfortable seat, etc.

These floatation devices and other industrial arts projects appeared on a number of television newscasts and had extensive newspaper coverage. As a result, similar problems were developed for a competition among 28 New Jersey schools. The new problems had to have one major consideration. They had to be judged primarily on an objective basis. In addition, the problems had to lend themselves to divergent solutions, be relatively inexpensive to solve, and be enjoyed by spectators. From this modest beginning in 1978 with 28 New Jersey schools participating, the OM membership expanded to over 4,400 schools in 1985-86. There are member schools in nearly all states in the US, several Canadian provinces, Australia, Pakistan, Saudi Arabia, West Germany, Taiwan, Okinawa, and Minilla.

Forty-six sanctioned OM Associations conduct competitions across the US and Canada. An association is a state, province, and Washington, DC. Several new associations are being formed at the time of this writing. The state/province champions compete at the World Finals. The 1985-86 World Finals was held at Northern Arizona University. Exactly 500 teams of five to seven individuals competed in the two- day event. Over 5,250 people stayed at the University and approximately 1,500 additional people stayed in the city of Flagstaff.

The 1986-87 World Finals will be held at Central Michigan University.

There have been several TV programs about OM. The first was a 1/2 hour TV special entitled "The Olympics of the Mind" which aired second in a 17-part series entitled "Creativity with Bill Moyers." The icing on the cake was that the series won an EMMY for the "Best Informational Series."

In another program, Walter Cronkite was host for a CBS television special entitled "I, Leonardo - A Journey of the Mind." The program described in detail many of Leonardo's scientific and artistic accomplishments. IBM presented the program without commercials and gave permission to videotape. Instead, during the usual commercial time, it presented a special message on education. The essence of the message was that we need higher educational standards not only in science and math but in reading and writing as well. All students should become technically literate. OM Association's creative problem-solving

competition was the focal point of this message. The problem featured was the (LDSC) "Leonardo da Vinci Spring Car." Each team had to design, construct, and drive an LDSC. Springs were the only source of energy permitted to move the vehicle. Vehicles were constructed and driven by team members. Vehicles had to be able to navigate a course and to be able to stop and back up with a reasonable amount of precision. During its journey, it had to change appearance from a 16th Century vehicle into a 1980's designed vehicle. The program showed youngsters describing their spring cars, competing with their cars as well as holding a discussion with Dr. C. Samuel Micklus, a founder of the OM Program. Mr. Cronkite said that the Olympics of the Mind is an encouraging sign of excellence in education. At the conclusion of the program, Mr. Cronkite went on to say, "What wonders await all of us.... IF, we are ready?"

Div. IV: College/University

The competition divisions are: (I) Grades K-5; (II) Grades 6-8; (III) Grades 9-12; and now (IV) College/University. Although lower divisions have five "long-term" problems, Division IV will have two. These "long-term" problems are disseminated months prior to the competition. The team with the highest long-term score receives 200 points, other teams receive a corresponding score based on percentage to the highest score. Spontaneous probelms are given to the teams the day of the actual competition. Spontaneous problems, have a maximum value of 100 points. The maximum is given to the team with the highest score with other teams receiving a corresponding score, again, based on percentage.

A third scoring category is "Style." Students are encouraged to develop unique presentations for their solutions. Style is an elaboration to the solution of the problem with a maximum value of 50 points. Here teams may include skits, costumes, music, potery, etc. Sometimes style categories are required and other times teams may have free choices. A parallel to style may be seen in the automobile industry. A car may be a basic means of transportation; however, style is an elaboration to include appearance, stereo, luxury seats, electric windows, etc. The combined scores of the long-term problems, spontaneous problem and style points determined how each team ranks in the competition.

Collegiate teams will follow the same procedures as all OM teams. They will be scored in the Long Term Solution and Spontaneous Problem Solution and Style. There will be 5-7 students per team, per problem. Member colleges/universities may compete in one or both problems. Each event is its own entity. A college membership is $100 to help defray expenses.

This year, membership will be limited to a number of colleges/ Universities who are affiliated with ITEA. Next year, expanding this number, again with ITEA members. The third year, related technologies i.e. Engineering, Architecture, etc. will be invited and then liberal arts institutions.

The site of the 1987 OM World Finals, Division IV competition will be in conjunction with the ITEA International Conference at Tulsa, Oklahoma. The OM Association will conduct the competition, provide judges, scorekeeping, awards, schedules, and programs. ITEA will provide competition space.

College students may participate via a club, an undergraduate course, a graduate course, or as an independent group. Thousands of youngsters participate in OM through high school. This enthusiasm could very well insure the success of Division IV.

Technology Education in Southeast Virginia's Public Schools

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Introduction

School systems in southeastern Virginia have been planning and developing technology education programs for the past decade. Implementation and teacher acceptance of technology education was slow in the early years. Some school systems and individual teachers sought help from the universities and state department of education in their understanding and education about technolgy education.

Today technology education has become a reality in the public schools of southeastern Virginia. This has resulted from the combined efforts of local school systems, Old Dominion University, and the Virginia Department of Education. Planning and staff development have been the keys to success in all localities.

From experience, when a school system wishes to transcend from industrial arts to technology education, they need to develop detailed plans that will lead to their projected path of success. If planning is omitted, problems, resistance, or modifications from the original intent occur. These problems seem to arise due to a lack of knowledge about what technology and technology education are and from the many issues related to change itself.

However, where planning and education have been developed into their plans of action, success has resulted. Following is a discussion of steps used in this change process that have proven to be successful in working with large school systems in southeastern Virginia.

Use Consultants

A teacher's job is teaching. Not many are schooled or efficient in curriculum change and development. Consultants can aid local supervision in planning for program change and provide additional rationale to teachers of the need and direction of change. Consultants can also guide and direct teachers in the development of new technology education programs. Remember that a teacher's main duty is teaching. He/she lacks time to revise or develop a new curriculum. Teachers usually do not possess proper training in technolgy education or curriculum development. However they need to understand the foundations upon which the curriculum is structured and they need to feel ownership of the new curriculum. Most importantly they need to be treated as professionals.

For supervisors to be effective in transitioning programs to technology education they need to understand the current trends in our profession and discipline. In addition they need to show leadership in the curriculum revision effort. Teachers usually do not follow or lead the way if strong supervision does not exist. Supervisors also need to support the new curriculum development efforts. For those teachers who adopt technology education, the supervisor needs to support them in the form of new resources, materials, equipment, and educational travel.

For consultants to be effective, they need to be recognized as scholars by the supervisors and teachers they are assisting. They also need to get the "right" prople involved to assist them in the curriculum revision efforts. This might include lead teachers or other experts in the discipline. In addition they need to have resources available to aid in the revision process. This might include other curriculum guides, reference books, films, activity kits, etc. Finally the consultant must be an organized individual who can guide the activity and make the teachers feel that they were involved in the curriculum revision process.

Define Structure

After the contents and the outcomes of a technology education program have been studied, a structure of what the program will look like must be designed. This should include course titles, units, and competencies. These will aid all involved in the many program development phases to come. Later in the paper the structures of the various school systems will be discussed.

Identify Teacher Leaders

Program change needs inside supporters. Identifying those teachers who are influencial to others and convincing them that the new programs are of value and meaningful to learners is a vital step. Those teachers will be important in the future. They will defend the changes and lead others to accept the new programs. Also these lead teachers should be involved in the program development and writing teams. They will be the early implementers or adaptors.

Develop the Instructional Materials

It is hard for teachers to implement a new program without instructional materials, i.e. competencies, objectives, teaching outlines, written materials, media, and activities. They need direction. Development of new materials should be based upon standards for technology education which include both the technical and social/ cultural content of the various systems. Remember the social/cultural content is the key. This is the major change in making contemporary industrial arts programs into technology education programs. Four major criteria have been used in all technology education programs developed by the school systems represented in this paper. These have included that they represent contemporary technology, are technology based (including social/cultural aspects), have "hands one" activities, and be developed in a competency based format.

Inservice on New Programs

All too often new instructional materials are developed and the inservice into why and how to use them is forgotten because of lack of time or resources. If this happens, teachers usually look at the new materials but feel they are for someone else. Consequently they get filed. Only those who developed them use them. The reason that this happens is that they have not been told why to use them or how. The extra time for inservice must be put into the master plan for the new materials to become instructional reality.

Inservice in Technology Education

A final step that needs to be incorporated into the change process is a re-education of the teaching staff. Some universities have restructured their undergraduate curriculums to be technology education programs. At Old Dominion University we have had a technology education program since 1979. However many teachers graduated before this change was made. For them, a planned series of graduate courses in technology have been developed and offered. Their contents include a philosophy and knowledge base for technology, analysis or technical systems, and a synthesis in program development. In addition, teachers should be technically updated by visiting local industries to observe and increase their understanding of new technologies.

Overall, technology education can become new life blood to our discipline. However, for this to happen, planning and re-education must occur.

Following are discussions of three southeastern Virignia school systems who have implemented technology education programs.

Chesapeake City Schools: Three years ago the then industrial arts program in Chesapeake could best be described as five years of woodworking with the same textbook being used in all courses grades 7-12. In addition there were not local curriculum guides, philosophy, or instructional goals, competencies, or

objectives. Courses offered had no sequence and also varied from school to school.

In our curriculum revision process, we began by forming a planning council composed of one teacher from each junior high and high school. This totalled twelve teachers. Meetings were scheduled monthly to develop a philosophy for technology education, establish course goals, and evaluate laboratory needs. Dr. Ritz was utilized as a consultant to aid in this planning process.

At the high school level, the first revisions were in the drafting and design sequence. In addition to adding CAD to the curriculum, other aspects of technology education were incorporated, including careers, reproduction methods, and industrial and societal practices.

Construction technology was also revised to place less emphasis on building skills and include more content as outlined in the various construction technology textbooks. This provided more of a technological background for the students who were previously studying the building trades.

During the past two years Dr. Ritz visited Chesapeake City School once a week for the entire day to work with teachers and instruct students in materials and processes technology and communication technology. Curriculum outlines, laboratory activities, and facility plans were developed. Through this pilot work, new programs will be offered at all Chesapeake High Schools in materials and processes and communication technology.

In addition to the work at the junior high and high school levels, Chesapeake City Schools have expanded technology education into the elementary schools. With the state of Virignia's increased academic graduation requirements, fewer students were having an opportunity to take courses in technolgy education. With this barrier in mind, it was decided that something innovative would have to be done to expose more Chesapeake Public School students to technology at an earlier age. Realizing that many students were enrolled in music education programs and had no schedule time for another elective, and that academically oriented student's schedules were almost nonflexible, Chesapeake decided to look at setting up a special summer program in Technology Education. With the assistance of the computer supervisor, a course was designed that would be:

- Inexpensive for students
- Exciting with highly motivational activities
- An introduction to technology and computer education
- Offered to students completing the sixth grade
- Long enough to accomplish our purpose
- Well publicized in the press to parents
- Called "Introduction to Technology"

The course was developed and has run for ten days with students spending two hours per day working with computers (taught by a computer education teacher) and two hours in a technology laboratory working with such things as robotics, rocketry, materials processing, and mass production. It was offered on a voluntary basis with students contributing $10 toward materials. This program has been offered the past two summers and in three Chesapeake junior high schools.

What came out of the course? In addition to the improved proficiency with computers, the students had an opportunity to study some of the technology found in their local environment. Some they made rockets, note holders, and key bobs. But more importantly they had an exposure to technology which otherwise would not have occurred.

Newport News Public Schools: Technolgy education in Newport News Public Schools begins with nine weeks in the sixth grade for all students except those enrolled in band. Seventh and eighth graders take one semester course in exploring technology or manufacturing.

The high school program begins in the ninth grade with survey courses in either power and transportation, communication, or construction technology. Tenth graders can begin to specialize in the areas of drafting, electronics, woods, or metals technology.

All instruction is in the competency based mode. This means Newport News follows four guidelines established in Virginia.

1. Competencies are specified to students prior to instruction.
2. Competencies are role relevant and derived by specialists in the profession.
3. A system exists for documenting student competency achievement.

4. Criterion reference measures are developed for each performance objective.

Developing these standards over the past eight years has produced curriculums written around performance objectives. Teachers and students are held accountable for mastering and teaching from the provided curriculum materials.

Middle School Curriculum

The middle school program in Newport News is actively based to provide students with experiences in both production and communication. The production lab is equipped with plastic, metal, and wood processing equipment. The communication lab is equipped with photography, graphic arts, drafting, and electiricity/electronics.

Exploring technology is a course that is one semester in length and uses the Maryland Plan methodologies for teaching the unit approach to study technology. This technique involves students in the learning process by requiring them to make decisions about their topic of exploration (an invention in the area of production, communication, or transportation) and designing a solution for their answer. This technique places more responsibility on the learner to do independent research. New processes are also introduced in graphic arts and photography.

Manufacturing at the eighth grade level focuses on product development and the production of a product. This course can take many different directions depending on the product and level of cooperative involvement. Robotics and computers are also introduced at this basic level. Students are learning the concpts of a pick and place robot. The computer is being used to assist with instruction and program management.

High School

Ninth graders have three technology education course options. These include construction, communication, or power and transportation. From this base they can continue to study with courses in basic technical drawing, electronics, wood technology, metal technology, graphic communication, computer electronics, and principles of technology. A new program is under development that will give students an opportunity to become master technicians. This combines the two fields of electronics and mechanics. Upon graduation from high school this student can continue on to a community college, university, or enter the job market. Advanced credit will be given at the community college level to students who complete this 24 unit program.

The Newport News' Technology Education program is proud of its progress and tradition. A strong foundation in the basics is being added to teaching problem solving and critical thinking. Technology education will also move into the elementary school as we begin a pilot project with NASA and Virginia Tech to teach a program on technological literacy to fifth graders.

Norfolk City Public Schools: Implementation of technology education programs has been undertaken in Norfolk for the past three years. Curriculum revision was first begun at the middle school level. University consultants worked with local teachers to develop a modified exploring technology program. The program was planned for eighteen weeks with concentrated study in the areas of communication, production, and energy and transportation. Our first curriculum revision was truly technological. All units included activities but had a strong emphasis into social/cultural content. Norfolk's exploring technology curriculum guide was divided into 180 daily lesson plans with transparency masters, handouts, project plans, and evaluative measures. The curriculum is a self-contained document to implementing technology education.

Last year our school system developed three self-contained curriculum guides for introductory high school courses in communication, materials and processes technology, and manufacturing. These were similar to our middle school materials in that they were competency based and included the social/cultural sides of these technologies. Each guide also contained transparency masters, handouts, project plans, and evaluative measures.

This past summer curriculum materials were developed for metals technology, basic technical drawing, engineering drawing, graphic arts, and woods technology. These were our advanced, specialized courses. All were developed similarly to our other materials.

Norfolk presently has plans to inservice its technology education teaching staff to assist them in the understanding of technology education and aid them in implementing their new curriculum materials. Overall this has been a vast new direction that has been accepted by

the teachers and administration of the Norfolk system.

Summary

For technology education to become a reality, all southeastern Virginia school systems planned and utilized resources to make the transition possible. It has been proven, by involving teachers and supporting them with resources and curriculum materials, technology education can replace industrial arts education and be more beneficial to our young people.

Assessing Students' Technical Reading Skills

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Introduction

The U. S. Office of Technology has predicted that by 1990 an estimated 75 percent of American workers will use a computer as part of their day-to-day duties. Until recently, organizing, sorting, storing and retrieving information via computer have been key operations restricted to the data processing centers of large organizations. However with the advent of microcomputers and accompanying application software, the capability for carrying out these operations electronically has been extended to all types of workers in both large and small organizations. Yet, on-the-job training programs for these workers are often quite limited, especially in small businesses which employ 50% of our work force and create two out of three new jobs.

Thus, the challenge of preparing workers for information processing tasks falls to our schools, especially our post-secondary technical and our high schools. Yet as headlined in *U.S. News and World Report* (Ahead: A Nation of Illiterates?, 1982), we are entering an era when growing numbers of Americans, estimated as high as one-third of our adult population, are not equipped with the functional literacy skills required for our emerging technological society. The question then becomes one of how can the technical reading and vocabulary skills these workers need be provided?

A first step in this process is to determine just what skills are needed and to what extent students preparing for information handling jobs have attained them. For processing information, five basic types of microcomputer software are used. Identified by Shea (1983), they include spreadsheet, word processing, database or filing system, accounting, and graphics software.

Many on-the-job users of these software programs must rely on limited computer literacy knowledge and use of the documentation manuals that accompany the software. However, most of the documentation manuals are prepared by individuals from the computer industry who specialize in progamming and in making the most of computer capabilities. Often, little concern is directed toward the reading skills of individuals who use the software. As O'Reilly (1983) notes, trying to use available software documentation manuals is like trying to fly around the world with a fifteenth century map. These manuals contain numerous terms that are unfamiliar to most of the intended users. Mezynski (1983), in assessing the effects of vocabulary on reading comprehension, points out that words in text vary in information value. She states, "Perhaps the proportion of unknown words per se is not as crucial as the number or proportion of high information words" (p. 261). Thus to cope with the reading demands of software documentation, the reader must have not only an adequate reading level but also technical terminology knowledge as well.

Research Implications

Today, Mace (1986) reports that database software is becoming the most frequently used software. Schmidt (1985) recently completed a study to examine the extent that high school business students exhibited the reading skills needed to comprehend database software documentation manuals. Two commonly used database software programs were used in the study, referred to as Software A and Software B. In Turn, two procedures were used to anlayze the reading skills required for the manuals. First, the FORCAST forumla (Caylor, et. al., 1975), the formula most applicable to determining the reading level of technical ma-

terials, was used. For the introductory materials analyzed from each manual, the reading level was 10.4 for Software A; while it was 11.6 for Software B. Second a list of unique technical terms that appeared in the manuals was compiled. A review of the manuals through the search/update procedures sections revealed 46 technical terms for Software A and 61 for Software B.

Subjects for the study were enrolled in Accounting I and II at three high schools. To assess the extent they had developed reading and vocabulary skills required for use of the manuals, a two part test was prepared. The first part was a Cloze test based on introductory materials from each manual. This part, therefore, had two forms, each containing 50 missing words. The Cloze procedure requires the student to insert missing words in continuing text, every fifth word. Students who insert 15 or less correct words out of the 50 are considered to be reading at the frustration level. Those who insert 16 to 24 words, the instructional level; and those who insert 25 or more, the independent level. The second part of the test contained 30 multiple-choice items constructed from the 104 technical terms. Interestingly, only three of the terms were common to both manuals. For the test items, fifteen terms were randomly selected for each manual.

Mean scores for the Cloze tests completed by the students were 18.4 for Software A and 12.7 for Software B. On the average, students completing the tests were able to read the Software A material at the instructional level and the Software B material at roughly 2 words below the frustration level. For the Software A vocabulary test, the mean was 7.3 while it was 6.8 for Software B test. The 211 students completing the multiple-choice vocabulary items averaged fewer than half of the items correct. The students participating in the study would have a difficult time using either documentation manual without help. An instructor planning to use this type of software documentation material with students would, thus, need to provide them with both technical reading and technical terminology instruction prior to and during their use of the manuals.

Technical Reading Material Difficulty

As outcomes of the study by Schmidt (1985) indicate, instructors must be concerned about the reading difficulty of materials they plan to use with students. Two procedures are available for this purpose: 1) the reading grade level of the material can be determined and 2) the technical terms the students are not likely to know can be identified.

The FORCAST readability formula (Caylor, et al., 1975) was developed for use with technical job reading matter of military personnel. It is based on counting the number of one syllable words in the material to be evaluated. The FORCAST formula is not appropriate for use with elementary and secondary school materials nor with newspaper and magazines. However, for material such as that contained in software documentation manuals, it is highly appropriate since it avoids the difficulty of recurring technical terms artificially raising the reading level. For a 150 word passage, the formula, which was named for its developers (FORd, CAylor, STicht) is:

$$\text{FORCAST} = \frac{20 - \#\text{ of one syllable words}}{10}$$

Ross (1979) computed the following scale for use of the formula with passages of less than 150 words:

- 47% one-syllable words = Grade level 13
- 53% one-syllable words = Grade level 12
- 60% one-syllable words = Grade level 11
- 67% one-syllable words = Grade level 10
- 73% one-syllable words = Grade level 9
- 80% one-syllable words = Grade level 8
- 87% one-syllable words = Grade level 7

To use the FORCAST formula, the instructor merely selects the technical material to be evaluated, counts the number of one syllable words in the material, and applies either the formula above or the scale computed by Ross.

Another procedure for instructors to use in evaluating the difficulty of technical reading material is to identify technical terms the material contains. These terms are the ones the students are not likely to know. If the list is extensive, then the instructor will want to implement teaching procedures for helping students learn the terms.

Students' Technical Reading Skills

Instructors must also be concerned with how their students' reading abilities match those required for technical materials. Again two procedures are available for this purpose: 1) the Cloze procedure (Taylor, 1953), which permits the instructor to measure the compatability of

printed material with the reading ability of students and 2) a pretest developed from technical terms the material contains.

For classroom use, the following adaptation of the Cloze technique is recommended by **Popham, Schrag**, and Blockhus (1975):

1. Randomly select reading material in six to nine passages and delete every fifth word in each passage. Stop when twenty words have been deleted.

2. In place of each word deleted, substitute an underscore.

3. Have the material typed, and instruct students to place in each blank a word that makes sense. No guessing or time restrictions permitted.

4. Analyze the answers and give credit for each substituion that approximates the original meaning. Determine a raw score for each student and convert that raw score to a percent by dividing the actual number of correct answers by the possible number of correct answers.

5. Determine the level at which the student comprehended the material by using the following formula: A score of 0-30% is Frustration Reading Level; a score of 31-49% is Instructional Reading Level; and a score of 50-100% is Independent Reading Level. (p. 127)

Developing a pretest based on technical terms from the material the students are to read will also provide insight into the extent they can understand the material. The test can be in a word-definition matching format or multiple choice format as Schmidt (1985) used. If a student answers less than half of the items on the test correctly, the instructor may assume that the qtudent will have difficulty reading the material.

Summary

Instructors must recognize problems their students may have in understanding technical materials due to limited reading ability and lack of technical terminology knowledge. Likewise, individuals who prepare technical materials must recognize these same limitations as they apply to workers whose jobs require use of such materials.

An instructor planning to use technical materials with students can use the procedures outlined in this paper in two ways. First, the difficulty of technical materials selected for students can be assessed. Use of the FORCAST formula will provide the reading-grade level of the materials and preparing a list of technical terms will provide insight regarding difficulty of teaching the material. In choosing an application software package, for example, an instructor can assess as described the documentation manuals of various packages to help determine the one most suitable for classroom use.

Second, after a software package has been selected, the instructor can then use the procedures outlined for determining the ability of students to read and understand the accompanying documentation manual. These include constructing a Cloze test (Taylor, 1953) and developing a pretest based on the technical terms from the manual. The Cloze test outcomes will indicate each student's degree of comfort with the reading materials-- frustration level, instructional level, or independent level. The terminology test will indicate terms the instructor must emphasize if the student is to understand the manual. Martin and Tolson (1985) reporting on a study of job trends across Virginia note that the 100 employers surveyed indentified four targets for educational emphases. The first of these is that basic skills be expanded to include reading and understanding technical materials. Thus educators, particularly at the secondary and post-secondary level preparing students for high technology jobs of today, cannot assume that their students come to them with all the reading skills they will need. Rather, these educators must face the challenge of helping students gain the "new" basic skill of reading and understanding technical materials.

An additional implication of this paper is that technical writers must become alert to the frustrations with reading and terminology that users of their materials can encounter. The advent of microcomputers and their acceptance in today's workplace along with ever more complex software makes this implication particularly important for technical writers in the computer industry. The publication *Simply Stated* (Designing Reader-Based Computer Manuals, 1983, p. 1), in discussing the need for technical computer manuals to be understandable, notes that such writers "...must learn and develop new strategies for reaching the diverse audiences who will be using their manuals." The effort to help workers cope with new reading demands imposed on them through

technology should come from at least two sources--through training provided by our educational institutions and through attention on the part of technical writers to the needs of novice users of materials they create.

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Technology Literacy Test

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During the past few years, there has been a growing concern over who will teach our citizenry about technology in our schools. One area of education that has accepted the challenge is Technology Education (an outgrowth of industrial arts). Technology Education is a part of general education, which teaches general concepts of industry and technology, in content areas of communication, transportation, construction, and manufacturing, with technological literacy as its goal.

> In a democracy where the claim is that all people should have a right to determine their future, a citizenry that is knowledgable of technology is important. Therefore, as a part of their general education all citizens should study fundamental technological systems as routinely as they acquire other skills for literacy. (Richter, 1980)

This philosophy is also backed by Robert Henricks, (1981) past president of the Wisconsin Technology Education Association. "If students are to be intelligent and productive members of society, they must be provided a broad conceptual understanding of industry and technology."

A great wealth of material has been written about technology education and more specifically the need for technological literacy. However, to our knowledge only two literacy tests have been developed in this area. One is by Dr. Jerry Richter in the area of communication. The other was a general technological literacy test developed by Anthony Gilberti, as a class project a Eastern Illinois University. Other content areas have been successful in developing literacy tests, such as agriculture and computer science.

> If technological literacy is to be the theme for technology education (as the family is to be the theme for home economics), then there needs to be a test indicating, in broad terms, the level of technological understanding of individuals. Other fields of study such as music or biology, lend themselves to tests devised to show how much a person knows of a subject. So, it is assumed this method could also be used in the area of technology. (Smalley, 1982)

The purpose of this study was to derive criteria which could be used to generate a test which indicates (in broad terms) the level of technological literacy for a 12th grade high school student in the United States in the 1980's. Since technological literacy is a realtively new area, only a few "experts" could be found. The "experts" were identified by the work they have done in the area of technological literacy written in books, magazines, and professional conferences. One goal of the research was to achieve a consensus toward test criteria. Therefore, the Delphi survey method was used. The Delphi consisted of three rounds, with the final round including sample test questions.

The criteria agreed upon by the expert panel were as follows:

1. Connect past technological events to the present and be able to project alternative futures.
2. Be able to solve technological problems.
3. Be a wise consumer/decision maker concerning technological products/services.
4. Understand the implications of career choices in the field of technology.
5. Understand reading materials in technological areas written on the 10th grade level.
6. Apply technological knowledge to a variety of human concerns and situations.

7. Knowledge of existing and emerging technologies.

8. Able to evaluate technologies as to their appropriateness in our world.

9. Able to understand and adapt to change brought about by technology.

Three multiple choice questions were developed for each of the nine criteria agreed upon. This original test was then administered by a variety of college and high school teachers to their students and results were tabulated. Based upon this data, many of the items were changed and the revised test is now ready for more extensive use.

This revised test has not been validated or standardized, but should be used as a teacher's tool to alert students and teachers to areas that are deemed important if one is to be technologically literate in the 1980's.

Technological Literacy Test (Revised)

1. What invention was most important in the development of the first television set?

   a. micro chip
   b. solid state resisters
   c. vacuum tube
   d. satellite

2. How many automobile companies were building cars in the U.S. in 1904?

   a. 57
   b. 32
   c. 19
   d. 4

3. The American space exploration program was only possible because of the development of

   a. new ceramic materials
   b. computers
   c. new navigational devices
   d. all of the above

4. Why has solar energy not achieved the widespread acceptance in 1985 that some had predicted 20 years ago?

   a. conspiracy of the oil companies
   b. acid rain has reduced the light intensity
   c. still more expensive to produce
   d. lack of government research funds

5. Which step in problem solving would immediately follow the initial selection of a problem?

   a. choosing the best solution
   b. brainstorming
   c. testing ideas
   d. selecting criteria

6. Which of the following would be most likely to get you up-to-date on a technical problem or solution?

   a. subscribe to a monthly magazine
   b. order a technical book
   c. read a research report
   d. interview a researcher

7. If you had to buy a VCR in one week, and two brands were the same price, which one is most important to help you make a choice?

   a. read the specifications
   b. try each one for several days
   c. ask people who had used one or both brands
   d. buy the one that looked the best

8. You find a product you recently purchased is unsafe. What is the best option for you?

   a. show it to all of your friends
   b. take it back to the store where you purchased it
   c. call the local newspaper with the story
   d. don't buy the brand again

9. When should you call an authorized repairman for your refrigerator?

   a. when you hear a "funny" noise
   b. when it won't work anymore
   c. after you have tried to fix it
   d. when nothing has bone wrong for six months

10. Which of the following careers is/are most affected by the use of robots?

    a. assembly line welder
    b. painter of tractor parts
    c. assembler of valve parts
    d. all of the above

11. Which of the following usually results with the introduction of computers in the manufacturing process?

    a. more skilled than unskilled jobs are created
    b. more unskilled than skilled jobs are created

c. fewer people work harder
d. most work less and get paid less

12. Which occupational area has increased the largest percent in the last 10 years?

a. medical services
b. communication
c. manufacturing
d. sales and services

13. Which of the following magazines would you refer to for an explanation of a current technological problem?

a. Fortune
b. Popular Science
c. High Technology
d. all of the above

14. Which of the following problems would best be classified as a technological problem?

a. When should you paint your house?
b. What car would you buy?
c. How do you insulate a home?
d. Why are some people overweight?

15. Read the following paragraph and then answer the question:

Develop a prototype of an office file server that can handle multimedia documents. That's the objective of an ESPRIT project being conducted by Battelle-Frankfurt. ESPRIT is the European Strategic Program on Information Technology. Its main purpose is to bring together European companies for research and development in pre-competitive areas to build more strength in thrust areas of common European interests.

Which of the following statements is true:

a. Europeans are going to mass produce a file server.
b. European companies are trying to develop a model for possible use in offices.
c. American companies are helping with the research and development.
d. This device will be built to handle documentation in several different languages.

16. Robots are being used to produce automobiles because

a. they produce better products cheaper
b. there is a shortage of skilled labor
c. of Japanese technology
d. they are easier to use on smaller cars

17. Which of the following will reduce the effectiveness of a passive solar system in a home?

a. small windows on the east and west sides
b. insulation in the ceiling and roof area
c. a good view through windows to the north
d. an overhang on the south side

18. What is the single major change in the last few years that has made the personal computer practical?

a. availability of large computers to connect to
b. development of the microprocessor
c. development of more software
d. ability of young people to operate the personal computer

19. What is a hologram?

a. laser produced 3D image
b. a telegram printed from a computer
c. a portable printer for a computer
d. a message received from a satellite

20. Which term is NOT associated with personal computing?

a. Byte
b. K
c. Menu
d. R.O.D.

21. CAD/CAM means

a. communication assisted digital computer aided memory
b. computer assisted design and memory
c. communication aided design and manufacturing
d. computer aided design and manufacturing

22. A third world country should not buy a high technology device until they

a. can pay for it
b. have the necessary infrastructure
c. see another country like theirs use it
d. can hire maintenance people

23. Technology innovation

a. usually comes from individual inventors
b. is limited to the technical area in which it occurs

c. can give rise to multiple social and economic changes
d. is better understood by most people than in early America

24. Which is an advantage of nuclear energy?

a. plant can be built anywhere
b. doesn't use scarce resources
c. plant is more dependable
d. cheaper to operate plants

25. What is the difference in new cars from those produced 40 years ago?

a. can't be fixed as easily by "shade tree mechanics"
b. don't last as long
c. need more repairs
d. are cheaper to operate

26. In the next 15 years, in which type of jobs will there be the largest increase?

a. high tech industries
b. low pay/low skill
c. skilled labor
d. sales and services

27. More education beyond high school will

a. make you more specialized
b. widen your options for a job
c. put you behind others in seniority
d. all of the above

Answers

1C, 2A, 3D, 4C, 5B, 6D, 7C, 8B, 9A, 10D, 11B, 12D, 13D, 14C, 15B, 16A, 17C, 18C, 19A, 20D, 21D, 22B, 23C, 24D, 25A, 26B, 27D

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Beyond Tasks and Competencies to Problem Solving in Technology Education

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Introduction

Although tasks and competencies are a necessary part of Technology Education, a focus must be placed on teaching thinking through problem solving so that students can remain technologically literate in a fast changing society and be competitive on national and international levels. It is insuffient just to teach the steps necessary to accomplish a task or to teach subject matter so that students can only recall the information. Students must be able to synthesize what they have learned and be able to apply it to new and different situations. Krulik and Rudnick (1980) of Temple University define problem solving as a process by which an individual uses previously acquired knowledge, skills, and understanding to satisfy the demands of an unfamiliar situation. Some higher-ability students may develop a process for problem solving as they practice solving many problems, but a significant proportion of students will not identify problem solving as a process and will experience high levels of frustration and avoidance when confronted with a new problem. Therefore, problem solving is a process that can and should be taught in virtually every class.

What is a Problem?

Perhaps this question appears simple, but a major difficulty in discussing problem solving seems to be a lack of agreement as to what constitutes a "problem" (Krulik & Rudnick, 1980). According to John Bransford of Vanderbilt University and Barry Stein of Tennessee Technological University (1984), a problem exists when an obstacle separates the present state from the desired or goal state. Without the obstacle there is no problem, so once the present and goal states are understood, it is the obstacle that is attacked in problem solving.

Krulik and Rudnick (1980) define a problem as a situation, quantitative, or otherwise, that confronts an individual or group of individuals that requires resolution, and for which the individual sees no apparent or obvious means or path to obtaining the solution. If the solution is obvious, there is no problem. For example, as people develop mathematically, what was once a problem becomes only a routine exercise. Krulik and Rudnick give the following three criteria that must be satisfied in order to define the existance of a problem:

1. ***Acceptance***: The individual must accept the problem. There is a personal involvement which may be due to any of a variety of reasons, including internal motivation (the personal satisfaction of solving a problem) or external motivation (peer, parent, and/or teacher pressure).

2. ***Blockage***: The individual's initial attempts at solution are fruitless. His or her habitual responses and patterns of attack do not work.

3. ***Exploration*** The personal involvement identified in number one (Acceptance) forces the individual to explore new methods of attack.

Compenents of Thinking and Problem Solving

Although there have been numerous problem-solving and decision-making models developed, there are common threads that run through each of them. One of the models that integrates many of the contemporary ideas and re-

search findings into an easily understood framework is the IDEAL model by Bransford and Stein (1984). The compancnts of this model are represented by the acronym IDEAL, from which each letter stands for an aspect of thinking that is necessary for problem solving.

In the IDEAL model the "I" represents the identification of the problem. This involves the ability to identify protentially solvable problems. Many problem-solving courses and books overlook this step because they emphasize solving a "given" problem. In the real world, problems may not be so easily identified. One reason for the failure to identify problems is that people do not think about the possibility of improving some inconveniences or unpleasant situations. They assume these situations are simply "facts of life."

It is interesting to note that the invention of the ball-point pen resultled from the efforts of two brothers who were proofreaders and found the use of fountain pens in their trade to be extremely messy and time consuming. The inconvenience of the fountain pen had been accepted by most, but Ladislao and Georg Viro identified a potentially solvable problem (Bransford & Stein, 1984).

Mail-order catalogs are full of inventions designed to solve various problems. An example is the "Ram Paw" ice scraper advertised to be the perfect solution to the problem of frozen windshields -- your hand remains warm and dry inside a water-resistant mitten, while the curved blade of durable plastic gives optimum scraping force. Unless someone had viewed "getting a cold hand while effectively scraping ice from a windshield" as a potentially solvable problem, it is not very likely that the "Ram Paw" ice scraper would exist!

The second aspect of the IDEAL approach to problem solving is defining the problem. Once a problem has been identified, it must be specifically represented. Several people may agree that a problem exists, yet they may disagree about how it should be approached because of their differing definitions of the problem. The problem definition is important in determining the problem-solving strategies to use. In the example of the ice scraper, the problem was degined as "how to effectively remove ice from the windshield while keeping your hand warm." What if the problem had been defined as "how to keep ice from forming on the windshield in the first place?" It is obvious that the ice scraper would not have been the solution.

Bransford and Stein state that problem identification or problem finding is often the most significant part of problem solving (1984). If students are taught only problem-solving strategies without problem identification and definition, they will have difficulty knowing when to apply the strategies. Problem identification not only refers to the recognition of existing problems, but to the awareness that current states of affairs may lead to future problems.

The "E" of the IDEAL model represents exploring alternative approaches for solving the problem. According to Bransford and Stein (1984), "this involves an analysis of how you are currently reacting to a problem plus a consideration of options or strategies that might be employed" (p. 18). It is necessary to analyze personal reactions to problems because sometimes people do not realize that they are trying to physically or mentally escape their problem situations. Bransford and Stein refer to these as the "let me out of here" approaches. Positive and explicitly directed approaches to problem solving appear to yield the most effective results. However, just wanting to solve a problem is not enough -- appropriate strategies must be used.

There are a number of effective probelm-solving strategies that can be taught in the classroom. One such strategy is the systematic approach, in which complex problems are broken down into several simpler ones that could each be solved. Almost all people seem to be more successful when they break complex problems into component parts.

For example, what if someone needed to know the largest sum of money -- all in current coins and no silver dollars -- he or she could have without being able to give change for a dollar, half dollar, quarter, dime, or nickel? Some people may "freeze" at the thought of having to solve such a problem, perhaps because they do not rely on problem solving strategies to help them achieve their goal. The problem is simplified by breaking it down into its component parts. First, look at each denomination of money separately (the dollar, half dollar, quarter, dime, and nickel), and determine the type and number of coins that would not allow it to be changed and whose sum is less than the denomination. Then combine all the coins that meet the previous criteria and try to make change for each of the given amounts. If this can be done, eliminate the smallest denomination of coin that allows change to be made. To be sure that one has the largest sum of money possible, check to see if a coin of any

denomination can be added without being able to make change for the given amounts.

The answer is $1.19, composed of a half dollar, quarter, four dimes, and four pennies. There may be different ways to approach this problem, but the point is that the problem is solved by solving its component parts, not by approaching it as a whole.

There are other strategies that are effective in problem solving, such as working a problem backwards. This approach is often taken when trying to meet a determined time deadline. For example, a young gentleman has a new job across town and he doesn't want to be late for his first day. He knows the time he must be at work, so the problem is determining the time he should leave home. Generally speaking, working backwards is an effective strategy whenever one knows the end or goal state of a problem, but the beginning state is not clear.

Working out a complex or abstract problem by focusing on a simpler, specific situation is another general problem-solving strategy. Attempting to solve a design problem on a scale model is an example of this strategy. Working with simplified simulations in laboratory settings is commonly used to solve problems found in the real-world environment.

It becomes obvious that the knowledge of problem-solving strategies is a very important element in reaching the goal state. There are other general problem-solving strategies -- too numerous to cover here. However, for additional examples, refer to *The Complete Thinker* by B. F. Anderson, *The Complete Problem Solver* by J. R. Hayes, or *How to Solve Problems* by W. A. Wickelgren.

The "A" in the IDEAL model represents acting on a plan ane the "L" represents looking at the effects. Once the appropriate strategy is selected, it must be acted out. Then a careful examination of the effects will reveal if the strategy worked. If the problem is solved, all has gone as planned. If not -- it's time to circle back. Perhaps another strategy would be more effective, or perhaps it may be necessary to redefine the problem.

Each of the components in the IDEAL model has important effects on the degree to which problems are solved. All five components are necessary for problem solving -- often the process may cycle through them a number of times for one problem.

Role of Specific Knowledge and General Concepts

Specific technical knowledge is necessary for solving problems. An adequate technical knowledge base allows one to represent the problem efficiently and to direct one's energy toward finding a solution. Knowledge allows for elaboration of the problem without a great expenditure of energy. Also, problems tend to seem less difficult when a person has sufficient knowledge in the area.

According to Branford and Stein (1984), the most powerful approach to problem solving is to become familiar with concepts that others have invented -- concepts that serve as tools and can be considered important elements of "general education." These would include such concepts as those in algebra, geometry, physics, economics, and psychology, just to name a few. Most areas of study "involve a host of core concepts and theories that people have found to be helpful for conceptualizing (defining) and solving important problems" (Bransford & Stein, 1984, p. 20). To develop effective problem-solving skills, one must learn about conceptual tools relevant to the problem.

Problem Solving and Creativity

In his book *New Think*, Edward de Bono (1967) discusses the difference between vertical and lateral thinking. Vertical thinking involves proceeding systematically from a single concept or definition (this can be associated with John Dewey and the Scientific Method), while lateral thinking involves seeking alternative ways of defining or interpreting a problem. De Bono (1967) gives the following example:

> Logic is the tool that is used to dig holes deeper and bigger, to make them altogether better holes. But if the hole is in the wrong place, then no amount of improvement is going to put it in the right place. No matter how obvious this may seem to every digger, it is still easier to go on digging in the same place than to start all over again in a new place. Vertical thinking is digging the same hole deeper; lateral thinking is trying again elsewhere.

There is a relationship between creative problem solving and the ability to think laterally. In order to think laterally, one may have to break away from common assumptions, which will often place unnecessary restraints on solving the problem. Many of the puzzles found in problem-solving books are based on the idea that most people will stick to their first as-

sumptions, which make it impossible to solve the problem.

Using the IDEAL framework as an example, creative or less creative strategies may result, depending upon where the cycle is reentered (assuming the first plan was not successful). The creative person will often redefine the problem, or at least closely examine the possibility. A redefined problem will lead to strategies that differ considerably from those used previously.

Problem Solving and Critical Thinking

Terms such as critical thinking or reasoning are often used interchangably with problem solving. Robert Ennis (1986), professor at the University of Illinois, defines critical thinking as "reasonable and reflective thinking that is focused on deciding what to believe or do" (p. 8). If one views critical thinking as the process of solving the problem "what should be believed or done", then the connection between the concpts is obvious. Ennis (1986) explains the connection in the following:

> Before considering a somewhat detailed presentation of the goals (of critical thinking curriculums) it would be helpful to have a broad look at critical thinking as I have defined it. Its focus is on the process of deciding what to believe or do. In making the decision, one starts with some information and assumptions and one infers to the decision. All of this should take place with due attention to clarity; it does usually take place in a context of interacting with other people, and there are dispositions as well as abilities involved in doing it well. Viewed broadly, this is problem solving, the problem being what to believe or do. (p. 8)

Characteristics of Good Problem Solvers

Researchers have found certain common characteristics that are exibited by good problem solvers (Krulik & Rudnick, 1980; Whimbey & Lockhead, 1981). The following is a summary of many of these characteristics.

1. ***Positive Attitude***: Good problem solvers believe that reasoning problems can be solved through careful, persistent analysis. They realize that a problem may appear confusing and that the way to solve it may not be obvious at first, but that through carefully breaking down the problem, a difficult problem can be gradually analyzed. Poor problem solvers seem to lack confidence; lack experience in dealing with gradual, sometimes lengthy, analysis; and have the attitude that either someone knows the answer or they don't.

2. ***Concern for Accuracy***: Good problem solvers make great efforts to understand the relevant facts and relationships fully and accurately. They may read a problem over several times or check any calculations they've made to make sure of their accuracy. Poor problem solvers lack such an intense concern, usually unaware of the importance of accuracy in understanding and technique.

3. ***Breaking the Problem into Parts***: Good problem solvers have learned that a complex problem must be analyzed by breaking it down into smaller steps. They attack the problem by starting at a point where they can make some sense of it. In contrast, poor problem solvers tend to look at the entire problem, and if they don't understand all of it, they dismiss the effort.

4. ***Avoid Jumping to Conclusions***: Good problem solvers tend to work problems from beginning to end in small, careful steps. They are not afraid to make educated guesses and then attempt to verify these guesses. They will gradually refine their guesses as their understanding increases, until they find a satisfactory solution. Poor problem solvers tend to jump to conclusions or make hasty responses without going through all the steps in the problem-solving process (good problem solvers are often able to skip some of the steps because they generally make connections quickly, notice irrelevant detail, and form generalizations quickly). Poor problem solvers tend to be careless in their reasoning and, at times, appear to give it up totally.

5. ***Activeness in Problem Solving***: Good problem solvers are often active in many ways which improve their accuracy and help them get a clearer understanding of ideas and problems. For example, they may try to create mental pictures, talk to themselves as they clarify mental pictures, talk to themselves as they clarify their thoughts, count on their fingers, make diagrams, write on the problem, or use any other aid to assist thinking.

Teaching Problem Solving

Teaching students to become good problem solvers involves both teaching the problem-solving process and teaching the subject matter for comprehension. Students who simply memorize new facts are frequently unable to use this information to solve new problems. Effective teachers attend to factual content, but they focus on developing an understanding of the significant or relevance of facts. Knowledge should be taught as a tool to be used in a wide variety of new situations, and not just as an end to pass a test.

Some teachers will respond by saying that they barely have time in a technical class to teach basic, essential subject matter, and that they could not possibly take time to teach the problem-solving process. However, teaching the process is not overly time consuming when taught in the context of the technical subject matter. A teacher may begin a new class by telling the students that during the course they will be analyzing and solving a number of problems involving that technical area. This sets the stage for the teacher to review the steps required in problem solving. The teacher will need to "walk" through the steps, using actual examples from the particular technical area. Students who have little practice in problem solving may experience some confusion and feel uneasy for awhile -- this is understandable, for they are being required in a sense to discipline their thinking processes. The reward is that problem solving becomes a way of life, not just something students learn so they can apply it now and then. Therefore, students have not only been educated in a particular technical area, but have been educated for life-long learning.

Once the teacher has reviewed the actual problem-solving process, what then? How can teachers assure that students will continue to practice and develop their problem-solving skills? The following ideas are but a few suggestions that may stimulate problem solving:

1. Teachers (and parents) should model the problem-solving process. They should allow the students to follow the process by verbalizing as they reason through each step. Modeling is a powerful teaching tool.

2. Positive attitudes are crucial. One of the biggest stumbling blocks for improving problem solving can be students' negative attitudes about their abilities. Lack of confidence in problem solving can manifest itself as a lack of interest, a fear of exploring new domains, or a fear of criticism. Working with a structured problem-solving model tends to increase students' success, thus improving attitudes.

3. Teachers should provide practice in problem solving. The ability to solve complex problems generally improves with practice. Academic problems for the students should be carefully planned to involve realistic situations and should be planned around the student's knowledge base.

4. Students should be taught to break down things into component parts. This is a process that Edward de Bono (1970) refers to a fractionation. It helps students notice functions and properties not typically associated with an object or idea, often freeing them from various limiting assumptions. Hence, students become able to approach problems from new points of view, which leads to lateral thinking and increased creativity.

5. Teachers should become knowledgable about and competent in using teaching strategies that promote problem solving. Strategies as simple as brainstorming or as elaborate as formal questioning can stimulate or assist in problem solving.

Why Teach Problem Solving?

There are several important reasons why problem solving should be taught in the classroom. First of all, an emphasis on problem solving lessens the gap between the real world and the world of the classroom. This increases the relevance of the subject matter, thus setting a more positive mood in the classroom. Also, problem solving is important in showing the interconnections among principles and ideas taught in technology education programs. Problems are never solved in a vacuum, but require previously acquired knowledge.

Students find problem solving much more exiciting, challenging, and interesting than working with routine exercises. Educators realize that success leads to persistence and continuation of a task, while failure leads to avoidance. Also, educators know that the greater the involvement, the better the end product in most cases. Therefore, students will be stimulated by a carefully selected sequence of problem-solving activities that lead to success. This will create a more positive attitude

toward technology education in general and problem solving in particular.

Teaching problem solving facilitates the use of a systematic rather than a hit-and-miss approach. Also, it increases the student's ability to select a variety of problem-solving strategies. Understanding the process tends to improve the student's willingness to approach problems positively, as well as increase the duration of effort and time spent reaching a solution.

Perhaps most importantly, problem solving allows students to practice self-education. It is this ability that permits students to continue cognitive expansion long past the classroom. Problem-solving skills are tools that today's students will require in order to adapt to tomorrow's world.

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Technological Literacy: An International Perspective

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Introduction

This paper is founded on three propositions. (1) The use of technological literacy as a term continues to be rather confusing. Within the framework of this paper, technological literacy is viewed as a *goal* of education. Technological literacy, however, is not necessarily an ultimate goal. (2) The *process* through which the goal of technological literacy is achieved must be technology education. But this is not necessarily technology education as perceived by professionals in the United States. (3) A growing number of countries are adding to the body of literature and experience in technology education. Despite the increased activity in this country, the United States is not the leader in technology education internationally.

Technological Literacy: Context and Meaning

The term technological literacy is widely used and serves as the pivotal concept of this paper. The phrase has been asked to serve many functions and with each new function there has been an attendant increase in ambiguity. If we are to use the term, we should continue to clarify its meaning (Scarborough and Blankenbaker, 1983; Foster and Perreault, 1986) rather than replace it with "scientific literacy" as some science educators have proposed. Examining the term in a larger context of meaning can illustrate that "literacy" is only one of the goals for a technologically responsible populace. In the taxonomy of "capacity for technological decision-making" described in Figure 1, five terms are proposed to clarify the position of technological literacy in a larger context.

The taxonomy embraces five levels of technological capacity: awareness, literacy, capability, creativity and criticism. As a corrollary to these five levels are five levels of competence: understanding, comprehension, application, invention and judgement. The first two levels deal primarily with what Gilbert Ryle has described as "knowledge that." Levels three and four reflect Ryle's notion of "knowledge why." This hierarchy of competencies represents the technological capacity of an individual skilled in making technologically related decisions. Within this framework "literacy" falls short of an ultimate goal of technological criticism and its corrollary competence of technological judgement.

Technology Education Internationally: A Framework for Interpretation

In preparation for this paper, information on technology education from twenty-eight countries was collected and reviewed. The world map presented in Figure 2 shows those countries by location and name. The geographical, economic, as well as conceptual diversities represented by these countries make it very difficult to present observations of a comparative nature. Because of the importance of such comparisons, even at the most general levels, a framework for interpretation was developed from selected earlier works (Todd, 1976; Todd, 1985).

Each country tends to view technology differently and consequently defines technology education in unique ways. There are obvious limits to what the concept can mean and consequently some commonality in meaning across different countries becomes apparent. The perspective on technology education often is founded during key stages of a country's development. The colonization of third world

countries often set patterns that remain in place long after colonization passed. Former members of the British Empire, although no longer under direct control of England, are decidedly English in ther educational outlook. Similar influence has been exerted on other countries by the United States, France, Holland, and Spain, to mention only a few. More recently, the educational systems of nations including Japan and Germany were shaped by the educational perspectives of occupying contries after World War II.

Within this paper, technology as part of the school curriculum takes six forms ranging from the specific and instrumental nature of technology to its more general or influential nature (see Figure 3). The instrumental aspect deals with how technology can be used in a direct manner to create intended changes in materials, processes, and the environment. The influential aspects deal with more indirect ways that technology creates unintended changes, particularly in the environment. The six forms include:

1. technology as *skills* particularly with emphasis on tool skills;
2. technology as a form of *motivation* that uses hand-on and project activities to add interest to other subjects;
3. technology as a *subject* in its own right with separately scheduled courses;
4. technology as an *end-in-itself* that provides conceptual frameworks for integrating content and skills learned in other subjects;
5. technolgy as a *guiding theme* that provides organizers for what is included in the curriculum and what students are to learn; and
6. technology as a *philosophical* perspective that includes a set of higher-level problem solving skills (Todd, 1985).

The six levels of meaning of technology were used to compare the differences among twenty-four of the countries that were considered in this study (see Figure 4). Analysis of statements from these countries identified the meanings of technology used within their educational settings. For each level of usage, one, two or three marks were recorded to indicate whether modest attention, substantial treatment or considerable emphasis is given to that use and meaning.

For example some countries such as Australia, Czechoslovakia and Japan give considerable emphasis to the skill aspect of technology education while England and Finland appear to place considerable emphasis on technology as a form of motivation. England, Finland, Sweden and the United States also use the term at several more general levels. England, for example, applies the term at all six levels to include a substantial treatment of technology as a philosophical perspective, particularly as it relates to problem solving.

The taxonomy of technology decision-making presented earlier in Figure 1 is based upon the premise that decision-making requires a fund of knowledge and background of insights that can be developed through the study of an involvement with technology. The pattern presented in Figure 5 was developed by analyzing the goal statements and objectives secured from selected countries (see Figure 6). The taxonomy, therefore, represents what a facet of the educational community of a country "intends" or hopes to accomplish through schooling. This, in fact, may be quite different from what "actually" is accomplished. The assessment of the congruence between the intended and actual accomplishements of these countries would represent a tremendously interesting focus for future inquiry but something far beyond the scope of this work.

A closer look at Figure 5 indicates that more developed countries attend, within technology education, to higher levels of technological decision making. This comes as little or no surprise since these countries usually have enough resources to provide a type of security for looking at higher level concerns represented in the taxonomy of decision making. Attention can be turned, therefore, to the effects of technology on a country or on the world. Less developed countries, on the other hand, are more concerned with survival issues and may have little time and resources available for the higher levels of the taxonomy.

Development of Technology Education Internationally

Over the past few years there has been an increase in international efforts that use technological literacy as a slogan and consider the study of technology as part of the school curriculum. The number of countries and agencies has expanded significantly beyond what this author reported less than two years ago (Todd, 1985). Selected examples of those efforts, both old and new, follow. In England

there is the work at the National Centre for School Technology at Trent Polytechnic in Nottingham, the National Network of Science and Technology Resource Centres, the Science Policy Research Unit at the University of Suffolk, the British School Technology Project at Nottingham and Bedford, the Technical Change Centre in London as well as the many universities and colleges involved in preparing technology teachers.

On the European continent, efforts are underway at the Study of Technology and Society programs at the University of Leiden and at the Techniche Hogeschool in Delft, both in the Netherlands. In Germany, there are the efforts of the Deutsbches Museum in Munich, as well as, the Wissenschaftzentrum and the Wissenshaftkollegium in Berlin (Riis, 1986). In France, the first steps of establishing technology as a basic school subject and integrating it with science were taken more than twenty years ago (Dodd, 1978).

There is also a growing body of research on attitudes of students toward technology emerging from the work of Jan Raat and his colleagues from the Netherlands. Starting at Eindhoven University this work involves colleagues from Australia, Belguim, Canada, France, Germany, Hungary, Kenya, The Netherlands, Nigeria, Poland, Sweden, The United Kingdom and the United States (Raat, 1986). The major focus of this research is to determine what 12-15 year old students think about technology in order to facilitate curriculum planning and technology course development (Raat and DeVries, 1986).

Additionally, there is a growing number of research groups in industry that are engaged in developmental efforts related to technology education. These include Economatics Ltd. in Sheffield, England, Lego Systems of Billund, Demark and Enfield, Connecticut, Fisher Technik of West Germany, and Creative Learning Systems of San Diego, California.

Activities in the United States include: (a) the Science, Technology and Society program of the Massachusetts Institute of Technology, (b) the Science, Technology and Society project at Pennsylvania State University, and (c) the work at Cornell University, Georgia Institute of Technology and Harvard University. To these must be added the growing number of state education department/university teams across the country with shared responsibilities for implementing new curricula in technology education and preparing technology teachers.

Internationally the experience and knowledge regrading technology education is now accelerating. There is also a tremendous willingness to share that experience and knowledge with others. This willingness to share has been rediscovered by a growing number of the technology professionals in this country over the past few years through their contacts with other professionals in England, Denmark, Germany, Australia, Japan, Thailand, Puerto Rico, and the Netherlands, to mention only a few.

Unfortunately, until very recently, technology education professionals in the United States could best or worst, be described as "technological isolationists." Through the efforts of the International Technology Education Association this separateness is changing, but not quickly enough. The profession allows findings and insights gained by colleagues from other countries to go relatively unheeded and unused and consequently continues to lose ground in technology education leadership. A few examples are considered below.

1. Technology and technological literacy is a matter of growing concern for all countries.

2. Technolgical literacy represents a source of powerful political support for educational reform.

3. There has been a general receptivity to attempts toward implementing technology as a part of the school curriculum.

4. Students have shown that they can perform at thinking and skill levels considerably beyond what teachers have expected in the past.

5. Students at all levels of schooling, from primary school to higher education, can become successful technology problem solvers.

6. Technology education of the "hands-on" type can be taught even if only modest budgetary support is intially available to schools.

7. Attitudes of students toward technology, as a basis for curricular planning, differ based upon sex and thier home country.

8. The "basic skills" of technology are emerging as different than those of industrially based programs. For example, mechanical drawing as it has been taught, appears to hamper a student's ability to communicate ideas on paper.

Yes, there is a great deal more for all of us to learn, and unlearn, from our international colleagues and a great deal more work yet to be done. Sharing internationally what has been learned and what must yet be accomplished will save years of work and time. Hopefully this is only a start!

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	LEVELS	TYPES OF KNOWLEDGE	COMPETENCE
I	Technological Awareness	Knowledge That	Understanding
II	Technological Literacy	Knowledge That	Comprehension
III	Technological Capability	Knowledge That & How	Application
IV	Technological Creativity	Knowledge That & How	Invention
V	Technological Criticism	Knowledge That, How & Why	Judgement

Figure 1: A Taxonomy of Capacity for Technological Decision-Making

Figure 2: Technology Programs Internationally

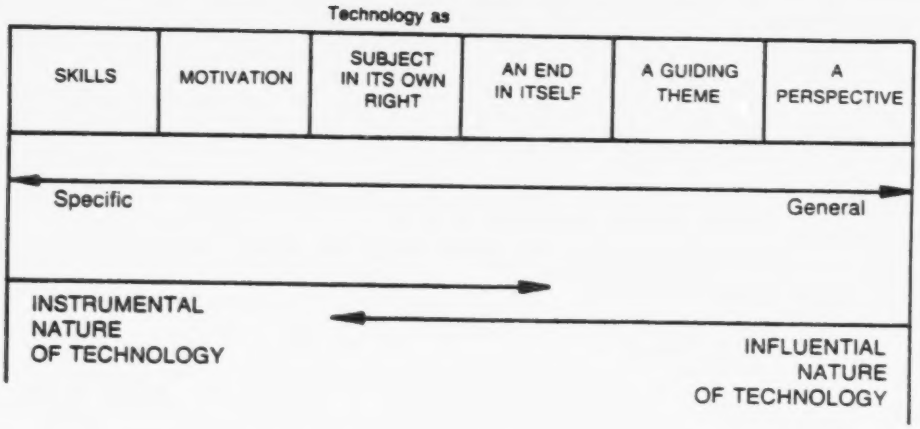

Figure 3: Forms of Technology

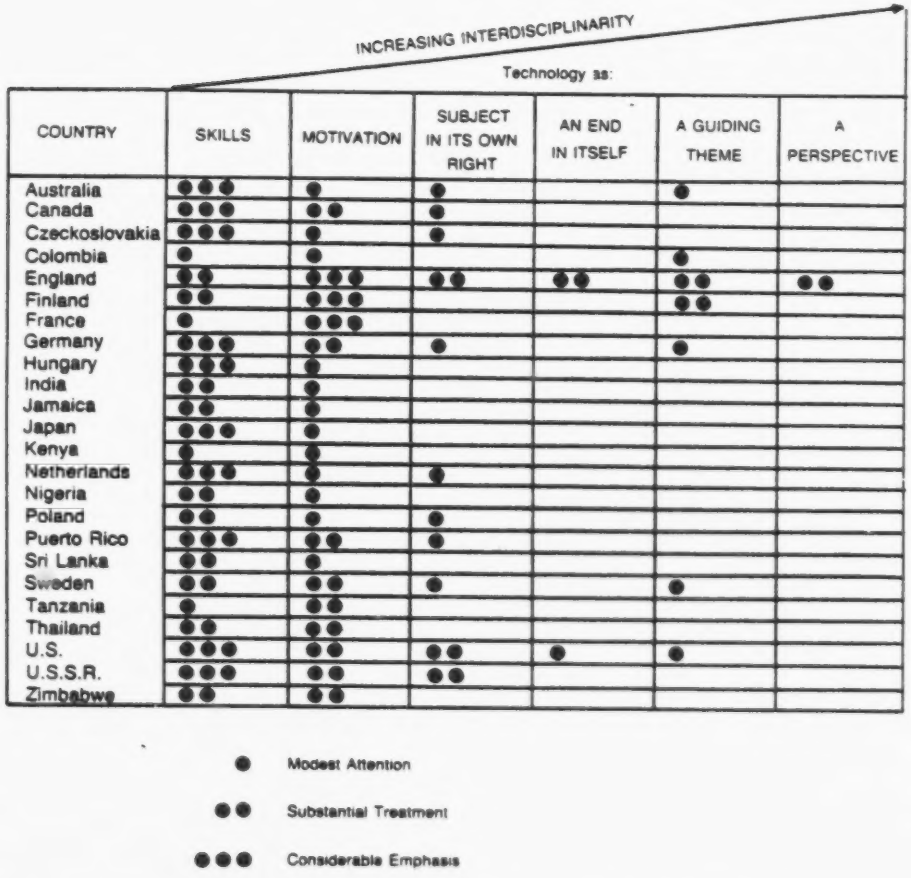

Figure 4: Technology Education As Identified Internationally

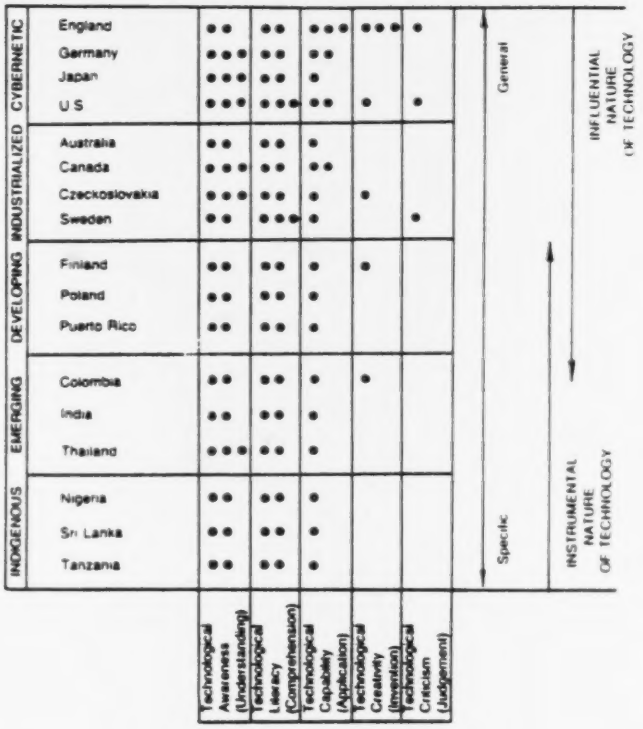

Figure 5: Taxonomy of Technological Decision-Making by Country

Figure 6: Selected International Goal Statements and Objectives

* To introduce the child to the world of work, and to inculcate in him a positive attitude to it (Sri Lanka), (Tissera, 1985).

* To provide for certain pre-vocational skills and make pupils proficient in simple skills relevent to a range of vocations (Sri Lanka), (Tissera, 1985).

* To help the learner to acquire the ability to expand his capacity for critical thinking through enquiry, experimentation and research (Tanzania), (Nkonoki, 1985).

* To train the student so as to enhance his capacity to make or construct things, be they models, devices, designs or simple machines, - with his own hands so as to build confidence in himself and the spirit of self reliance (Tanzania), (Nkonoki, 1985).

* To help children learn problem solving through "the scientific method" (Colombia), (Cruz Cardona, 1985).

* To help stuents gain a positive attitude toward scientific and technological developments and to make rational use of technical devices, (Colombia), (Cruz Cardona, 1985).

* To enable students to become involved in at least some part or parts of the technological design process (India), (Maheshwari, 1985).

* To develop in all pupils a broad understanding and critical appreciation of scientific and technological advances and an awareness of their impact locally/globally, (India), (Maheshwari, 1985).

* To teach the students to critically assess the environment and when choosing the available services and commodities to consider the technical qualities, aesthetic, economic, and environmental factors (Finland), (Kananoja, 1985).

* To develop skills that allow the students to apply theoretical knowledge to problem solving processes (Czechoslovakia), (RITVE, 1985).

* To help pupils to acquire knowledge and skills relevant to adult life and employment in a fast changing world (England), (DES, 1986).

A Leadership Model for Implementing Technological Literacy Education

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Introduction

Arnold Toynbee once described the rise and fall of nations in terms of challenge and response. A young nation, he said, is confronted with challenges for which it finds a successful response. It then grows and prospers. But as time passes, the nature of the challenge changes and if a nation continues to make the same once-successful response to the new challenge, it inevitably suffers a decline and eventual failure. As technology education enters the end of the 20th century it faces a similar challenge.

In my travels around the central and eastern part of United States, I have had the opportunity to visit school shops and laboratories in diverse settings and distant geographic locations. As I reflected on my past school visits, I was struck by a resounding echo: how to stimulate more innovative, more enterprise, more initiative with our profession to implement technological literacy into the local programs.

Persons who review the publications in technology education (TE) will find numerous articles and references about curriculum and instructional change. If, however, an individual specially analyzes the publications for information about working with local TE teachers on altering their human behavior to implement change, little if anything is found.

As I first looked at the 1986 35th ACIATE Yearbook, *Implementing Technology Education*, I felt "ah ha," finally I have some written material in my profession to help me prepare for my presentation. Unfortunately, it was short lived. As I reviewed the chapters the word curriculum was repeated over and over and over. At the end of the first chapter, the authors did identify actions to take, but nothing to deal with the human element of TE teachers and change.

Definitions

Change may be defined as the transformation of attitudes, norms, institutions, and behaviors that restructure our daily lives (Burns, 1978). Kanter (1983) identified change as a process that involves the crystallizing new action possibilities (new policies, new behavior, new patterns, new methodologies, new products, new ideas) based on reconceptualized thought patterns. For this presentation, change is a process of anticipating need for and altering the attitude and behavior of people and organizations in such a way to gain acceptance of a new idea, new system, new product, or new methodology.

Implementing tehcnological literacy education is defined as follows: a psychodynamics process that mobilized new and existing motives found in industrial arts/technology teachers and the organization in which they function to institutionalize the ever changing technology centered materials and instructions. To accomplish the implementing technology process, a special form of leadership is required. The leadership must consider the educational culture, structure, and climate (environment) so as to influence the human organization in a positive and visionary way that enable classroom and laboratory innovations to be incorporated.

Why the Gathering Storm?

Let's start by asking three big questions:

1. Why have reform movements or specific

products failed to win acceptance in the marketplace?

2. Why were the great curriculum and instructional reform movements in educaiton during the 1960's and 1970's (including industrial arts education) unsuccessful in implementing more lasting change?

3. How can the technology education (TE) people implement their ideas and products into the university and local schools so change actually does occur in the traditional industrial arts programs?

Need for Change

The Biblical prophets of old found themselves consistently telling the people to change their ways before it was too late. Certainly, we can remember Don Lauda's comments back in 1972 at the Dallas AIAA Conference, stating if we do not change industrial arts we will be a thing of the past. Before Lauda, William Warner and his students provoked great debate over technology as the content for our profession. These professionals and numerous others have attempted to raise our level of consciousness to create change. Again, why has actual change been so difficult? Perhaps we have a high threshold for change.

The matter of threshold can be illustrated by the "boiled frog phenomenon." The story comes from a classic physiological response involving two live frogs, a pan of water, and a Bunsen burner. The first frog is placed in a pan of cold water. The pan is heated using the Bunsen burner and the heat is turned up very gradually. If the change is gradual enough the frog will sit in the pan until it boils to death. The animal could have jumped from the pan any time, but the change in environment happened so gradually that no response was triggered in the frog and death ensued.

When the second frog was placed in a pan of boiling water, it promptly jumped out, and survived. We can manipulate the temperature of the water and determine at just what rate of change would cause the first frog to jump out. Regardless, the analogy is clear, like the frog, there are people and organizations that do not respond to triggered events in their environment to recognize that a catastrophic situation is coming. The profession of shop education, people and the organizations, have in many ways become boiled frogs because their threshold of awareness is set too high. The moral of the story gives two responses. First, to change, turn up the heat on teachers drastically. Second, lower the threshold of teachers through human resource development so change will be more comfortable.

Entrepreneurial vs. Revitalization Change

The recent example of the rags to riches phenomenon found in American business/industry have been promoted as "entrepreneurs" by Peters and Waterman (1983). The individual include Ray Kroc (McDonald's Hamburger), Steven Jobbs (Apple Computer), Bill Gates (Micro Soft software), and Clement Stone (Insurance) to name a few. These individuals have been characterized by myths and legends that reinforce important leadership values. Less well published people have been those leaders whose job it is to revitalize an existing organization where there are myths and legends about bad habits that must be broken (one exception, Lee Iacocca of Chrysler).

Change through revitalization requires that people and the organization come together to meet changing environmental conditions. The difficulty is that people tend to quickly as possible reduce their work to a standard routine. The change that does occur in the environment is screened through a person's valued routine. Therefore, the trick for the leader is to bring about change by adjusting people's threshold to a more sensitive level which tends to create a need for change. Unfortunately, lowering the threshold is at best very difficult, for people go to great lengths to protect their routine and the work image (Ticky & Devanna, 1986).

Question About the Storm

The gathering storm about implementing technology education has been with us for several decades. Recently, however, the storms are building to hurricane intensity. In short, the heat has been turned up. The change advocates are joyously anticipating their success. The big question yet to be answered is: Will this flurry of activity actually change the local school organization and shop teachers to Technology Education?

The list of problems associated with failure to implement change deals basically with the wrong leadership. The style and tone of society have changed over the past several decades (Hickman & Silva, 1984). Burns (1978) stated that there is a crisis in leadership due to an in-

adequate knowledge about its purpose and practice in a changing culture. The most information about leadership models for change and how to accomplish it is found in the corporate environment (Kanter, 1983).

Even with the plethora of new management approaches and techniques, leadership consultants and academicians continue to fail because the corporate users who try to follow the advice have not made fundamental changes in their attitudes and approaches (Hickman and Silva, 1984). What is needed said Michael Maccoby (1981), author of *The Leader*, is a new model of leadership that expresses an ethic of self-development for all employees of large businesses, government, unions, and non-profit organizations.

The Challenge: Creating a New Vision of Change

Implementing technological literacy education at the societal organizational or individual classroom level means dislocation and/or discomfort (Ticky & Devanna, 1986). Before change can occur there must be a period of disintegration which brings on the discomfort and dislocation; a result of resistance to change (Burns, 1978).

Organizations can change if individuals do it first (Hickman & Silva, 1985). The change leader to be effective, must understand how people deal with change. Most of us know the difficulty, pain, or agony that we go through to change bad habits. Nothing is more true than when changing the bad habits of smoking and overeating. The old ways of doing things subtly begin to sabotage our attempt for long-term change.

A Transforming Leadership

The type of leadership needed to implement technological literacy education into American classrooms and laboratories must relate to transforming the individual teacher into his/her better self. It is the transforming leadership process that builds on a teacher's need for meaning and purpose in a hectic atmosphere, a leadership style that fosters an innovative institutional culture.

Burns (1978) talks about two types of leadership, one, transactional and the other, transformational. Transactional leadership is a rewards punishment relationship where if the follower gives time, energy, or votes, the leader will give some reward. It is merely an exchange of one thing for another. Transactional leadership may have been fine in stable times and under specific situations. But, today in a rapidly changing world and mobile population a high moral relationship must exist between leader and follower. Burns defined this relationship as transformational leadership with an explanation given in the following:

> Transformational leadership occurs when one or more persons engage with others in such a way that leaders and followers raise one another to higher levels of motivation and morality...Various names are used for such leadership--elevating, mobilizing, inspiring, exalting, uplifting, exhorting, evangelizing...Transforming leadership is dynamic leadership...with followers who feel "elevated" by it, and often become more active themselves, thereby creating a new cadre of leaders (p.20).

Transforming leadership is designed for change, innovation, and implementation of the entrepreneurial spirit (Ticky & Devanna, 1986). The Burns (1983) definition of transformational leadership fits well the definition of implementing technological literacy education and change process in general since it focuses on the human element in change.

A Vision to Meet the Challenge

What is a vision? Hickman and Silva (1984) stated "Essentially, vision is a mental journey from the known to the unknown, creating a future from a mantage of current facts, hopes, dreams, dangers, and opportunities" (p. 151). The importance of holding a clear vision was found by Bennis (1985) in his extensive research with ninety of the top leaders in various fields and professions. The results indicated that the common behavior of all top leaders was that they held a clear vision--a dream of their work.

The challenge of a transformational leadership process is both to find and create a vision of that organization which in some way is better than the old one and encourages others to share that dream (Ticky & Devanna, 1986). Transforming leadership involves creating larger visions and engaging teachers' imagination in pursuit of them (Kanter, 1983). Technology teachers must create a vision and share it with others because it releases needed energy to propel them and the organization into action.

A Transformational Leadership Model

In the search for transformational leadership models to implement change, I went to the corporate world and studied the following experts: Drucker, 1985; Hichman and Silva, 1984; Iacocca, 1984; Neisbitt and Aburdene, 1985; and Ticky and Devanna, 1986. There are two reasons I went to corporate America rather than education. First, the corporate world is facing the greatest struggle to survive competition and shrinking profit margin. As a result they are driven to implement change and basically they are looking at human beings as the secret. Second, technology education attempts to copy the products, practices, and concepts of modern industry. Therefore, it is only natural for me to use information from the literature dealing with reinventing of corporate America which can be used as an analogue for revitalizing technology education.

The building blocks of change (Kranter, 1983) are as follows:

1. Must depart from tradition (Internal), starts at the grass roots; look at people's behavior and the organizational culture and structure.
2. Use crisis or galvanizing event (external); lawsuits, crisis, new technology.
3. Apply strategic decision making, not as the lock-in guide, but as an effort to secure support and planned direction.
4. Comprehend the need for Individual "Prime Movers;" these people are empowered champions who push and push and push for change.
5. Make use of action vehicles through communication, training, and development, building support systems, and social-political-work networks.

A Leadership Model for Change

Hickman & Silva (1984) suggest six skills that are needed for the new age executives. They are as follows:

1. ***Creative Insight***: Asking the right questions. Using insight to adapting critical perspectives to strike at the heart of the problem.
2. ***Sensitivity***: Doing unto others. People are an organization's greatest asset. The transformational leader must comprehend how to bind them together into a culture where they feel truly motivated to achieve. Face to face communication, ongoing training, creative incentive programs and job security.
3. ***Vision***: Creating the Future. The ability to journey with a clear vision from the known to the unknown. The vision unified strategy and culture. It provides scenarios to gain a future focus.
4. ***Versatility***: Anticipating Change. The ability to sense and prepare for the ever changing world gives the transformational leader the opportunity to use change as a positive force rather than a negative blow.
5. ***Focus***: Implementing Change. This skill is the topic of this paper. Nothing happens after all the activity of change unless it is implemented. By focusing, leaders and local teachers can eliminate unfocused activities and understand the steps to successful implementation.
6. ***Patience***: Living in the Long Term. This includes controlling impatience, reducing stress level, achieving well being, and creating the ideal environment to carry out the implementation process.

Implementing Technological Literacy Education

The first part of the presentation dealt with the growing storm about the inability of technology education to implement change. The second part of this presentation attempted to create a vision to meet the challenge of the gathering storm. The suggested solution was to employ a dynamic transformational leadership model that empowers local classroom and laboratory teachers to rise above themselves to embrace technolgical literacy education. This section will deal with moving from theory to practice.

Step 1: The study of these change elements can provide the knowledge information base for incorporating the transformational leadership model, the type needed to implement technological literacy education. They include: participation, networks, teams, communication, human relations, motivation mobilizer, occurring culture, politics, influencing, visions, self regard, revitalizing, collaboration, support, threshold, networks, entrepreneurship, empowerment, normative re-education, fulfillment, strategic planning, power tools, action

group, involvement, intervention, parallel organizations, incentives, recruitment, transition, integraion, productivity, climate, restructuring, etc.

Step 2: Comprehend the three stages of the change cycle (adapted from Schein, 1969).

- Stage 1. Unfreezing or ending present behavior.
- Stage 2. Changing or transforming.
- Stage 3. Refreezing or Solidifying of behavior.

Step 3: Select as a transforming leader the best general strategy for effecting changes for individuals in specific situations as adapted from Chin and Benne (1969). The three strategies are as follows:

1. ***Empirical-rational strategies*** - People are rational beings and will follow their own self-interest. Changes are obtained by people knowing of a situation that is desirable, effective, and in tune with self-interest. This strategy has not worked with changing deep seated values and beliefs or persons and groups.
2. ***Normative-re-educative strategy*** - It rests upon the assumption and hypotheses about humans and their motivation. Humans are inherently active in finding their impulse and need satisfaction. Change in normative orientation involves change in attitudes, values, skills, and significant relationships rather than mere change in knowledge, information, or rationale for change action.
3. ***Power-coercive approaches*** - It is based on the application of power in some form either political or otherwise.

The best change strategy for our transformational leadership model is number two, normative re-education. It works on the free conscious and subconscious teacher's actions. It is desinged to propel rather than compel teachers. Great emphasis is placed on releasing the creativity of teachers to accelerate change and enhance their personal and profesional growth.

Step 4: Plan for transition. The leader needs to understand the basic purpose of an organization through a required conceptual map to guide the efforts of change. It includes the technical, political, and cultural aspect of the organization and persons involved with the implementation (Ticky & Devanna, 1986).

- Technical questions might be: what is the flow of information, what are the work flow patterns, what are social political work flow network vehicles?
- Political questions are: Who are the target people and groups, what is the plan to gain commitment, is there a monitoring system, have key influential people when analyzed to determine their attitudes towards desire change?
- Cultural questions are: Have the culture values and beliefs been determined, have the gatekeepers of current culture been identified, is there a plan to change gatekeepers to feel a need for change, is there a monitoring system to support change?

These three factors (technical, political, and cultural) interact with varying intensity to give the transformational leader the basic knowledge needed to proceed to actually setting the stage for implementing change.

Step 5: Focus on implementing change. It is impossible to reach success without focus. Focusing positions the implementation change process to center stage to give it the individual attention required by a leader. It sends messages to the persons involved that the leader is serious and committed to a specific change.

Hickman and Silva (1984) have identified five substeps to implementing change as given in the following adaption:

1. Identify the change, specifically relating it to the school organization strategy and culture. Determine what teachers, administrators and board members need in terms of skills, organizational structures, operating systems and management orientations to implement change.
2. Quantify the level of effort and resources needed to bring about each of the changes in substep 2.
3. Develop a plan and time table for shifting focus to elements involved in the implementation change process. Never ask the school to implement more than two high effort changes at a time.
4. Stand steadfastly to implementing change, monitoring progress closely, and making necessary adjustments along the way.

Step 6: Use human resources appropriately. The thesis of this presentation is that the transformational leadership model halps people grow and develop. The leader can implement change if the human resources of teachers, administrators, and community members are developed through the change activity.

Step 7: Form an Implementing Change Task Force. The basic job of the transforming task force is to generate a vision of what technological literacy education should be, then turn it into reality.

Step 8: Apply an Operational Leadership Strategy, that is a well defined plan built upon objectives and hard work.

Innovative Strategies for Implementation

The following are new ideas or strategies that might be used for implementing change:

1. Professional associations can be even more assertive as change agents. Their power comes from numbers and they have the freedom to operate outside of any existing bureucratic educational system. ITEA could establish a task force that visits state associations and local school districts to serve as transformational leadership teams.

2. School districts should establish an innovative idea council that would serve as a place where new ideas could be given a full hearing.

3. School districts could deregulate their technology education program by opening them up to external bidders e.g., IBM, AT&T, or some Japanese firm might provide a way of continuously providing updated technological literacy education to students at perhaps a lower cost than the school district could.

4. Have American and/or foreign high tech companies provide the teacher preparation technical content skills and inservice updating. The professional education training would be done at the university in cooperation with selected school districts.

Summary

The ability of technology education people to implement change in the local classrooms and laboratories throughout America has been difficult. History tells us that the forces at work in an organization or profession mount to stop the institutionalization of change. To continue the revitalization of technology education requires a constant push by entrepreneurial champions who have incorporated the transformational leadership behavior.

If technology education advocates operate as pointed out by Marshal McLuhan's memorable statement-they were driving into the future while looking out the rearview mirror-change will continue to be difficult. Perhaps we should follow what George Santayana once observed-that in our changing world we should no longer salute our ancestors but bid them farewell (Bennis, Benne, Chin, 1969).

Implementing technological literacy education requires that the transformational leaders answer three important questions about their competency. First, do they have the "power skills"--skills in persuading others to invest information and support? Second, do they have the ability to manage problems associated with greater use of teams and participative decision making? Third, do they have the understanding of how change is designed and constructed in the organization-blending individual development with the organizational goal achievement (Kanter, 1983)? Leaders armed with these skills and knowledge can expect positive results through dedicated persistence.

The Challenge

Whether the promise of this leadership model works depends on how fully the technology leaders at all levels understand the need and decide to act on it. It depends upon whether we can come to embrace change, to see it as an opportunity, and thus to stimulate the people in our organization to take action to master it. As a professional, we can no longer afford to do otherwise.

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